BIOSENSORS 2024

6th International Congress on Biosensors Konya/Türkiye

BIOSENSORS 2024

5-7 September 2024

NECMETTIN ERBAKAN UNIVERSITY

6th INTERNATIONAL CONGRESS ON BIOSENSORS

ABSTRACT BOOK

Necmettin Erbakan University, Konya/Türkiye

6th INTERNATIONAL CONGRESS ON BIOSENSORS

5-7 SEPTEMBER 2024

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KONYA/TÜRKİYE-2024

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FOREWORD

Dear Participants and Colleagues,

On behalf of the Organizing Committee, I would like to express my sincere appreciation for the valuable contributions of all the participants of 6th International Congress on Biosensors, which was successfully held between 5th September and 7th September, 2024, in our beautiful and historical city Konya, Türkiye.

6th International Congress on Biosensors covered all aspects of biosensing technologies where nanotechnology and engineering sciences play a role, including fundamental and applied sciences. It offered plenary, keynote and invited presentations on cutting-edge topics by internationally renowned leaders of the field, followed by contributed talks, vendor seminars, and workshops relevant to the European Union Projects, and poster presentations to stimulate interdisciplinary discussions as its long traditions of it.

Konya, located in the Central Anatolia Region of Türkiye, which has been the cradle of many civilizations throughout history, and also on the Silk Road route, one of the most important trade routes in world history, is today one of the unique centers combining its historical heritage and cultural accumulation. Konya, which witnessed the birth of many civilizations throughout history, have also become one of the important centers in the field of science and wisdom. Turkish influence that started to appear after the Seljuks conquered Anatolia and outstanding madrasahs, libraries, palaces and mosques of Anatolia started to be erected in Konya. Scholars, scientists, philosophers, and poets were always respected and protected in Konya palaces. It is also an ocean that each of the scholars individually like Mevlâna Jalâl ad-Dîn Rûmî, Shams Tabrizi, Sadrettin Konevi, Nasreddin Hodjas and many others is considered as a river unifies within. It is a full of peace city that embeds tolerance seeds wavy into the hearts of the people.

The venue of the 6th International Congress on Biosensors, there is a large complex of auditoria (Prof. Dr. Erol Güngör Congress Hall) in the Campus of Necmettin Erbakan University. It is favorably located in the heart of the city, an area very close to the historical places such as Mevlana Museum.
In addition to the scientific program, exciting social events were organized. We hope that you enjoyed incredible landscapes, unusually quiet places, world-famous cuisine, the central history of Anatolia and a very rich cultural tradition. It gave the participants a chance to experience Turkish history and culture along with traditional Turkish hospitality.

On behalf of the Organizing Committee, I would like to mention my gratitude to the Rector of Necmettin Erbakan University who gave full support for the Congress Organization. The special thanks go to The Scientific and Technological Research Council of Türkiye (TÜBITAK), Metrohm Turkey, Renishaw, Terra Lab, Agon Biotechnology, Referans Kimya, Galvanoplot, and Springer (Microchimica Acta Journal). I would like to present a special thanks to sustainability committee members for their fundamental work in motivating us to propose the organization of this congress. In addition, 6th International Congress on Biosensors was organized successfully, without any professional support, with the contribution of all our colleagues. Therefore, the members of the organization committee of the congress definitely deserve a great thank.

Yours Sincerely,

Congress Chair,
Assoc. Prof. Dr. Erhan Zor

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SCIENTIFIC PROGRAMME

05. 09. 2024 THURSDAY		
08:00–17:00	**REGISTRATION**	
09:00–09:30	**OPENING CEREMONY**	
SESSION 1	**Chair of the Session: Prof. Dr. Gustavo Rivas**	
09:30–10:15	**Plenary Lecture "Prof. Dr. Arben Merkoçi"**	*Revolutionizing Health and Environmental Diagnostics: The Future of Nanobiosensors*
10:15–10:30	Oral Presentation 1 "**Petru Epure**"	*Measuring Setup for Body Fluids Evaluation*
10:30–10:45	Oral Presentation 2 "**Alper Demirhan**"	*Design of an Electrochemical Impedance Spectroscopy Instrument for Ingestible Biosensors*
10:40–11:00	Oral Presentation 3 "**Sina Ardalan**"	*Regeneration of Screen-Printed Gold Electrodes by Air Plasma Cleaning*
11:00–11:15	**TEA–COFFEE BREAK**	
SESSION 2	**Chair of the Session: Prof. Dr. Aziz Amine**	
11:15–11:45	**Invited Lecture 1 "Prof. Dr. Zeynep Altintas"**	*Microneedle Array-Based Smart Patches for Multiplexed Monitoring And Therapy of Chronic Wounds*
11:45–12:00	Oral Presentation 4 "**Rajalakshmi Sakthivel**"	*Self-Powered Photoelectrochemical Immunosensor Using MIL-88A Derived NiFe LDH Double Shell Nanocages with TiO_2/PCN Heterostructure for the hCG Detection*
12:00–12:15	Oral Presentation 5 "**Melike Bilgi**"	*A Disposable Label-Free Electrochemical SMRP Immunosensor*
12:15–12:30	Oral Presentation 6 "**Dilsat Ozkan-Ariksoysal**"	*Electrochemical DNA Nanobiosensors Containing Carbon Nanotubes or Graphene Oxide Derivatives and Examples of Their Current Applications for Genetic Disease/Drug-DNA Interaction Analysis*
12:30–13:30	**LUNCH**	
SESSION 3	**Chair of the Session: Prof. Dr. Suna Timur**	
13:30–14:10	**Keynote Lecture 1 "Prof. Dr. Almira Ramanaviciene"**	*Advances and Challenges in Nanomaterial-Based Immunosensors*
14:10–14:25	Oral Presentation 7 "**Sevda Akay Sazaklioglu**"	*3D Mini Electrochemical Cell Fabrication and Impedimetric Detection of CEA Using the Pencil Graphite Three-Electrode System*
14:25–14:40	Oral Presentation 8 "**Merve Yılmaz Çılçar**"	*Point-of-Care Testing: A Disposable Electrochemical HE4 Immunosensor*
14:40–15:00	**TEA–COFFEE BREAK**	
SESSION 4	**Chair of the Session: Prof. Dr. Mamas Prodromidis**	
15:00–15:40	**Keynote Lecture 2 "Prof. Dr. Gustavo Rivas"**	*Biofunctionalized Carbon Nanostructures: Specialized Legos to Build Electrochemical Biosensors?*
15:40–16:10	**Invited Lecture 2 "Dr. Attilio Marino"**	*Self-assembled Brain Tumor-on-a-Chip: Implementation, Sensorization, and Drug Screening*
16:10–16:25	Oral Presentation 9 "**Gulsu Keles**"	*Development of an Electrochemical Tyrosinase Biosensor Incorporating Selenium-Conjugated Polymer and Amine Functionalized Quantum Dots for Catechol Detection and Inhibition Applications*
16:25–16:40	Oral Presentation 10 "**Meltem Agar**"	*An Aptamer-molecularly Imprinted Polymer Electrochemical Sensor for Bacteria Detection in Water*
16:40–17:00	**TEA–COFFEE BREAK**	
SESSION 5	**Chair of the Session: Prof. Dr. Almira Ramanaviciene**	
17:00–17:30	**Invited Lecture 3 "Prof. Dr. Eden Morales-Narvaez"**	*Nanophotonics for the Next Generation of Biosensors*
17:30–18:00	**Invited Lecture 4 "Assist. Prof. Dr. Hamed Golmohammadi"**	*Smart Optical Sensors for eDiagnostics and eMonitoring*
18:00–18:15	Oral Presentation 11 "**Emre Dokuzparmak**"	*Developing Molecularly Imprinted Polymeric Nanoparticles and Iridium-based Optical Sensors for Amphetamine Type Stimulants*
18:15–18:30	Oral Presentation 12 "**Nedim Hacıosmanoğlu**"	*Coupling Plasmonic Metasurfaces with Fluorescence for Enhanced Detection of Microplastics in Real-samples*

06. 09. 2024 FRIDAY		
08:30–13:00	**REGISTRATION**	
SESSION 6	**Chair of the Session: Prof. Dr. Stefano Cinti**	
09:00–09:40	**Keynote Lecture 3 "Prof. Dr. Aziz Amine"**	*Recent Advances in Biosensors Based on Molecularly Imprinted Polymers and Nanozymes*
09:40–09:55	Oral Presentation 13 "**İlker Polatoğlu**"	*Design of DNA-Inorganic Hybrid Based Signal Platform for GMO Detection with Personal Glucose Meter*
09:55–10:10	Oral Presentation 14 "**Nimet Yildirim-Tirgil**"	*Development of an Electrochemical Impedimetric Biosensor System through Selection of DNA Aptamers Targeting Parathyroid Hormone (PTH)*
10:10–10:25	**TEA–COFFEE BREAK**	
SESSION 7	**Chair of the Session: Prof. Dr. Arunas Ramanavicius**	
10:25–11:05	**Keynote Lecture 4 "Prof. Dr. Mamas (Mamantos) Prodromidis"**	*Generation of Nanomaterials via Spark Discharge: A Rapid, Environmentally Friendly, and Versatile Method for In-Situ Modification of Electrode Surfaces*
11:05–11:35	**Invited Lecture 5 "Assoc. Prof. Dr. Stefano Cinti"**	*Paper-Based Opportunities in Sensors Development*
11:35–11:50	Oral Presentation 15 "**Vasfiye Hazal Özyurt**"	*Development of Electrochemical Sensor for the Detection of Chloropropanols that are Important for Food Safety*
11:50–12:05	Oral Presentation 16 "**Ayşenur Yılmaz Kabaca**"	*Label-Free Electrochemical FOLR1 Immunosensor Prepare Using a Hand-Made Disposable Electrode*
12:05–12:25	**Vendor Seminar 1 "Renishaw"**	*Renishaw and Biosensor Applications*
12:30–13:30	**LUNCH**	
SESSION 8	**Chair of the Session: Prof. Dr. Eden Morales-Narvaez**	
13:30–14:10	**Keynote Lecture 5 "Prof. Dr. Suna Timur"**	*Various Applications of Multiplexed Testing Systems*
14:10–14:35	**Vendor Seminar 2 "Metrohm"**	*Metrohm Electrochemistry Solutions*
14:35–15:05	**Invited Lecture 6 "Prof. Dr. Noureddine Raouafi"**	*Laser-Induced Porous Graphene Electrodes for (Bio)Sensing*
15:05–16:00	**POSTER SESSION**	
SESSION 9	**Chair of the Session: Prof. Dr. Zeynep Altintas**	
16:00–16:40	**Keynote Lecture 6 "Prof. Dr. Arunas Ramanavicius"**	*Electrochemical sensors based on conducting polymer - polypyrrole*
16:40–17:10	**Invited Lecture 7 "Assoc. Prof. Dr. Fatih İnci"**	*Micro/Nanoscale Marvels Spanning From Sublime Minutiae to Intricate Designs*
17:10–18:00	**Workshop 1 "Prof. Dr. Mustafa Ersöz"**	*Towards 2025 Calls in Horizon Europe & Networking*
18:00–18:30	**Workshop 2 "Prof. Dr. Meltem Demirel Kars"**	*Experiences on Coordinating a Horizon Europe Twinnig Project: REGENEU*
19:00	**GALA DINNER**	

07. 09. 2024 SATURDAY		
SESSION 10	**Chair of the Session: Prof. Dr. Noureddine Raouafi**	
09:00–09:40	**Keynote Lecture 7 (Online) "Prof. Dr. Gianni Ciofani"**	*Brain-on-a-Chip Devices: Real-scale Sensorized Models*
09:40–09:55	Oral Presentation 17 "**Sezin Yuksel**"	*3D-Printed Electrochemical Biosensor Applications for Clinical Analysis*
09:55–10:10	Oral Presentation 18 "**Nur Melis Kılıç**"	*Endocrine-Disrupting Compound Detection on Electrospun Nanofibers*
10:10–10:30	**TEA–COFFEE BREAK**	
SESSION 11	**Chair of the Session: Assist. Prof. Dr. Hamed Golmohammadi**	
10:30–11:10	**Keynote Lecture 8 "Prof. Dr. Uğur Tamer"**	*Design of Microfluidic Chip Platforms for Pathogen Detection*
11:10–11:40	**Invited Lecture 8 "Annika Järvinen"**	*Parametric Surface Plasmon Resonance: Advanced Measurement Principle for Biosensing Applications*
11:40–11:55	Oral Presentation 19 "**Zehra Taş**"	*Integration of Raman Spectroscopy into Microfluidic Platforms for Biomedical Applications*
11:55–12:10	Oral Presentation 20 "**Amal Rabti**"	*The Use of Redox-Active Polymers in Capacitance-Based Aptasensors for Enhanced Food Safety*
12:30–13:30	**LUNCH**	
SESSION 12	**Chair of the Session: Assoc. Prof. Dr. Saniye Söylemez**	
13:30–13:45	Oral Presentation 21 "**Marina Serin**"	*Development of a Prototype Aptasensor to Determine the Severity of Demyelination*
13:45–14:00	Oral Presentation 22 "**Elif Atay**"	*A Novel Functionalized Nanofiber Based Biosensor for the Detection of Listeria Monocytogenes*
14:00–14:15	Oral Presentation 23 "**Esma Yıldız**"	*Electrochemical Biosensing of Interaction between Aptamer and Indium(III) Phthalocyanine Conjugate Targeted Photodynamic Therapy of Breast Cancer*
14:15–14:30	Oral Presentation 24 "**Canan Can**"	*Development and Application of Borophene Quantum Dots (BQDs) in Biosensors*
14:30–14:45	Oral Presentation 25 "**Melike Orkan**"	*Francisella Tularensis Detection via a Novel, Fast and Safe Electrochemical DNA Biosensor Employed with Graphene Quantum Dots as Nanozymes*
14:45–15:00	**TEA–COFFEE BREAK**	
SESSION 13	**Chair of the Session: Assist. Prof. Dr. Nimet Yildirim-Tirgil**	
15:00–15:15	Oral Presentation 26 "**Dilek Soyler**"	*Design of Functional Fullerenol-Based Electrochemical Nanobiosensors*
15:15–15:30	Oral Presentation 27 "**Ezgi Adak**"	*A Novel Acetylcholinesterase Biosensor for the Determination of Pesticides*
15:30–15:45	Oral Presentation 28 **"Sarsenbayeva Aliya"**	*Electrochemical Immunosensor Based on Molybdenum Compounds for Diagnosis of Acute Myocardial Infarction*
16:30–17:00	**CLOSING CEREMONY & AWARDS**	

POSTER SESSION 06. 09. 2024 FRIDAY / 15:05 – 16:00	
PP1	A Label-Free Electrochemical DNA Biosensor for the Rapid and Sensitive Detection of Ebola Virus Gizem Ören Çıbık, Sümeyra Savaş
PP2	Detecting Point Mutations in Genomic Human DNA Using Electrodes Modified with DNA-Tethered Nanomaterials and TMB/MB as Redox Signal Reporters Sabrine Baachaoui, Marwa Meftah, Ouassim Ghodbane, Noureddine Raouafi
PP3	Development of a Novel Electrochemical In Vitro Assay for Real-Time Neurotoxicity Assessment Hasret Türkmen, Mustafa Şen
PP4	Miniature Impedimetric Hemoglobin Immunosensor for Detection of Gastrointestinal Bleeding Alper Demirhan
PP5	Metal-Organic Framework-Derived Hierarchical Flower-Like DyCo-Layered Double Hydroxide Integrated Nitrogen-Doped Graphene for Diphenylamine Detection Subbiramaniyan Kubendhiran, Lu Yin Lin
PP6	Colorimetric Detection of CD36 on Electrospun Nanofibers Zeynep Elcim Koru, Dilek Odaci
PP7	Polymer-clay Nanocomposite as an Immobilization Matrix to Prepare Enzyme Biosensors Belguzar Karadag, Yagmur Aktepe, Damla Huriye Topdemir, Esra Evrim Yalcinkaya, Dilek Odaci
PP8	Development of Different Screen Printed Electrodes Based Sepsis Biosensors and Determining the Most Effective Biosensor System Sudenaz Erfaki, Hatice Öztürk, Mirsu Yurdagül, Yudum Tepeli Büyüksünetçi
PP9	Development of Electrochemical and Colorimetric *Escherichia Coli* Detection Systems Based on Benzoquinone Nursima Uçar, Didem Aksu, Suna Timur
PP10	Development of Lateral Flow Immunosensor for Detection of Growth Hormone Eda Gumus, Haluk Bingol, Erhan Zor
PP11	Electrochemical Detection of Foodborne and Human Pathogen *Staphylococcus aureus* using Graphene Quantum Dots Melike Orkan, Sumeyra Savas
PP12	Polymer-Based Encapsulation of Flavonoids via Electrospinning for Nutraceutical Applications Deniz Tuğçe Algan, Erdal Kocabaş
PP13	Monitoring of Palladium in Living Cells and Environmental Samples with a New Sensitive Fluorescence Sensor Ayse Betul Altun, Duygu Aydin, Mehmet Oguz, Serkan Erdemir
PP14	Comparative Performance of ZnO Nanoparticle-Modified Working Electrodes: Exploring the Impact of Electrode Selection Abdurrahman Taha Gülderen, Gülşah Öztürk, Ali Akbar Hussaini, Deniz Ulukuş, Murat Yildirim, Yasemin Oztekin
PP15	Development of Graphene Oxide-Based Label Free Electrochemical Genosensor for the Detection of *E. Coli* Sezin Yuksel, F. Ferda Yilmaz, Huseyin Tasli, Pinar Kara
PP16	Multi-walled Carbon Nanotubes Modified Electrochemical DNA Biosensor Design for Determination of the Interaction between DNA and Favipiravir Drug Used in the Treatment of COVID-19 Merve Cenikli, Fadime Mullahmetoglu, Rabia Ozturk, Dilsat Ozkan-Ariksoysal
PP17	Multisensing Portable Tool Based on Novel Fullerenol Derivatives for Health Status Monitoring Lucian-Gabriel Zamfir, Raluca Ianchiș, Saniye Soylemez, Salih Özçubukçu, Mihai Mitrea, Petru Epure, Cătălina Gîfu, Iuliana Răut, Mariana Constantin, Cristina Firincă, Maria-Luiza Jecu, Mihaela Doni, Ana-Maria Gurban
PP18	Biosensing Approaches in the Development of Innovative Opto-Electrochemical Portable Tools for Food, Clinical and Environmental Applications Ana-Maria Gurban, Lucian-Gabriel Zamfir, Petru Epure, Mihai Mitrea, Cristina Nistor, Iuliana Răut, Mariana Constantin, Cristina Firincă, Cătălina Gîfu, Cristian Petcu, Bogdan Trică, Maria-Luiza Jecu, Mihaela Doni
PP19	Preparation of Imprinted Plasmonic Biosensors in Factor VIII Detection Serok Devrim Aydoğan, Yeşeren Saylan
PP20	A Reduced Graphene Oxide-Based Electrochemical Aptasensor for N-Nitrosamines Detection Mehmet Emin Çorman, Veli Cengiz Özalp, Erhan Zor, Manolya Müjgan Gürbüz, Burcu Doğan Topal, Lokman Uzun

PP21	Electrochemical and Spectrofluorimetric Investigation of the Interaction Between dsDNA and 2,6-Diisopropylphenol Doga Ekin Orhan, Ahmet Cetinkaya, Eda Nur Aybi, Sibel A. Ozkan, Burcu Dogan Topal
PP22	Investigating the Direct Electrochemical Detection of 5-Hydroxymethylcytosine with Reduced Graphene Oxide Modified Pyrolytic Graphite Electrodes in Biological Samples Manolya Müjgan Gürbüz, Selva Bilge, Hüseyin Çelikkan, Burcu Doğan Topal
PP23	Investigation of Ritonavir-DNA Interaction by Spectrophotometric and Electrochemical Methods Manolya Müjgan Gürbüz, Aysun Dinçel, Burcu Doğan Topal
PP24	An Electrochemical Sensor Based on ZnO Nanoparticle-Assisted Molecularly Imprinted Polymer for Highly Sensitive and Selective Determination of Clozapine Fatma Budak, Aykut Kul, Ahmet Cetinkaya, S. Irem Kaya, Selen Al, Olcay Sagirli, Sibel A. Ozkan
PP25	Production of a Molecularly Imprinted Polymer-Based Sensitive and Selective Electrochemical Sensor Using Prussian Blue Nanoparticles for the Specific Recognition and Determination of Chloroquine Phosphate Ensar Piskin, Ahmet Cetinkaya, Mehmet Altay Unal, Briza Perez, Udara Bimendra-Gunatilake, Yannick Guari, Joulia Larionova, Eva Baldrich, Sibel A. Ozkan
PP26	Detection of Roxadustat in Dosage Forms and Biological Samples: A Highly Sensitive Electrochemical Approach by Using Glassy Carbon Electrodes Mahdi Gharibi, Pinar Ozdinc, Ahmet Cetinkaya, Nurgul Karadas Bakirhan, Esen Bellur Atici, Sibel A. Ozkan
PP27	A Novel Electrochemical Sensing Platform Combined with Molecularly Imprinted Polymer and VMXene NFs Composite for Highly Selective and Sensitive Determination of Methionine Ahmet Cetinkaya, Sevilay Erdogan-Kablan, Havva Nur Gurbuz, Aytekin Uzunoglu, Emirhan Nemutlu, Sibel A. Ozkan
PP28	Benzotriazole Decorated Conductive Polymeric Layer for the Selective Electrochemical Determination of Heavy Metal Ions Sena Pişkin, Pınar Kapçı, Erdoğan Özgür, Deniz Hür, Lokman Uzun
PP29	Molecularly Imprinted Electrochemical Sensor for Selective Detection of 2,4-Dinitrotoluene Tunca Karasu, Ahmet Burak Berk, Sena Pişkin, Erdoğan Özgür, Lokman Uzun
PP30	A Novel Electrochemical Sensing with Molecularly Imprinted Polymer for Highly Selective and Sensitive Determination of Anticancer Drug Sevilay Erdogan-Kablan, Ahmet Cetinkaya, Esen Bellur Atici, Emirhan Nemutlu, Sibel A. Ozkan
PP31	Development of a Molecular Imprinted Polymer Sensor Designed by Electropolymerization for Anticancer Drug Detection Seyda Nur Samanci, Göksu Ozcelikay-Akyildiz, Esen Bellur Atici, Sibel A. Ozkan
PP32	Investigation of the Effect of BDT-Based Conjugated Polymer Nanoparticles for Biosensing Applications Dilara Yeniterzi, Oguzhan Karakurt, Ali Cirpan, Saniye Soylemez
PP33	Investigation of Glucose Sensing Ability of Ni-Based Metal Organic Frameworks Dilek Soyler, Saliha Mutlu, Bülend Ortaç, Ali Karatutlu, Taylan Görkan, Engin Durgun, Nergis Arsu, Sevil Savaskan Yılmaz, Saniye Soylemez
PP34	Development of a Carbon-Based Sensor Using Voltammetry Techniques for the Determination of Daptomycin and Application in Different Environmental Samples Nida Aydogdu Ozdogan, Ersin Demir, Sibel A. Ozkan
PP35	Evaluation of the Electrochemical Behavior of the Janus Kinase Inhibitor Abrocitinib in Biological Samples Using Glassy Carbon and Boron-Doped Diamond Electrodes Zeynep Alakus, Ahmet Cetinkaya, Esen Bellur Atici, Sibel A. Ozkan
PP36	Development of an Electroanalytical Method on a Boron-Doped Diamond Electrode for the Determination of the Anti-Cancer Drug Palbociclib in Biological Samples Melike Akan, Cigdem Kanbes-Dindar, Nazife Aslan, Bengi Uslu
PP37	Advancing Melatonin Detection: A New Electrochemical Sensor Using Molecular Imprinting Nanotechnology Nurgul Karadas Bakirhan
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6th International Congress on Biosensors

LECTURES

Plenary Lecture

Arben Merkoçi
The Catalan Institute of Nanoscience and Nanotechnology, Spain

Keynote Lectures

Almira Ramanaviciene
Vilnius University, Lithuania

Arunas Ramanavicius
Vilnius University, Lithuania

Aziz Amine
Hassan II University of Casablanca, Morocco

Gianni Ciofani
Italian Institute of Technology, Italy

Gustavo Rivas
Universidad Nacional de Córdoba, Argentina

Mamas I. Prodromidis
University of Ioannina, Greece

Suna Timur
Ege University, Türkiye

Uğur Tamer
Gazi University, Türkiye

Invited Lectures

Eden Morales-Narvaez
National Autonomous University of Mexico, Mexico

Noureddine Raouafi
University of Tunis El Manar, Tunusia

Zeynep Altintas
Kiel University, Germany

Fatih İnci
Bilkent University, Türkiye

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Hamed Golmohammadi
Chemistry and Chemical Engineering Research Center of Iran, Iran

Attilio Marino
Italian Institute of Technology, Italy

Annika Järvinen
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Revolutionizing Health and Environmental Diagnostics: The Future of Nanobiosensors

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I will examine the transformative potential of nanobiosensors, emphasizing their application in clinical and environmental contexts. Leveraging the unique electrical and optical properties of nanomaterials, these sensors are poised to revolutionize point-of-care diagnostics.

Nanomaterials such as graphene and nanoparticles exhibit remarkable properties that are crucial for sensor development. Graphene's exceptional electrical conductivity, high surface area, and biocompatibility make it ideal for creating highly sensitive and selective sensors. Nanoparticles, with their tunable optical properties like surface plasmon resonance, enhance the detection of biological molecules at ultra-low concentrations.
The presentation will highlight a range of nanobiosensor applications, including graphene-based electrical sensors for detecting cancer biomarkers, nanoparticle-enhanced optical sensors for rapid COVID-19 detection, and versatile sensors for monitoring environmental analytes such bacteria and some pollutants. These examples demonstrate the broad applicability and efficacy of nanobiosensors in addressing both health and environmental challenges.

Importantly, these nanobiosensors are designed to fulfill the REASSURED criteria, making them particularly suited for point-of-care diagnostics. REASSURED stands for Real-time connectivity, Ease of specimen collection, Affordable, Sensitive, Specific, User-friendly, Rapid and robust, Equipment-free or minimal equipment, and Deliverable to end-users. The integration of nanomaterials into paper-based devices, such as lateral flow assays, exemplifies this, as they are not only cost-effective and scalable but also portable and easy to use in various settings, including resource-limited environments.

By meeting these criteria, nanobiosensors ensure that diagnostics are accessible, efficient, and reliable, facilitating real-time, on-site detection. This capability is essential for timely medical interventions and effective environmental monitoring. As such, nanobiosensors represent a significant advancement in personalized healthcare and environmental stewardship, making precision diagnostics more widely available and impactful than ever before.

Advances and Challenges in Nanomaterial-Based Immunosensors

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One of the major challenges in bioanalytical chemistry is the sensitive detection of biomarkers present in biological samples at low concentrations. To address this, various immunoanalytical techniques and immunosensors have been developed. Recent advances in nanoscience and nanotechnology offer new opportunities to enhance the performance of optical, electrochemical and acoustic immunosensors. Surface plasmon resonance (SPR) immunosensors are the most prevalent optical immunosensors, primarily chosen for their distinctive capability to directly monitor biomolecule binding events in real-time. Nonetheless, their sensitivity is not always sufficient to directly detect ultra-low quantities of target biomarkers. However, with the rapid advancements in nanotechnology in recent years, nanomaterial-enhanced SPR immunosensors have emerged and proven to be more effective [1-4].

This contribution will delve into the most critical and highly promising trends and challenges in the applications of nanomaterials, focusing particularly on the utilization of gold nanoparticles, gold-coated magnetic nanoparticles and quantum dots. The most important and highly promising trends and challenges in application of nanomaterials for labeling of detection antibodies used for the enhancement the analytical signal of the SPR immunosensors will be discussed. Special attention will be given to the development of reusable immunosensors used to detect biomarkers in real samples. Various strategies for enhancing the signal of SPR immunosensors using nanoparticles will be presented. This information holds significant value as it lays a solid foundation for the design of forthcoming ultra-sensitive immunosensors.

.**Keywords:** optical immunosensors; nanoparticles; signal amplification strategies.

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Biofunctionalized Carbon Nanostructures: Specialized Legos to Build Electrochemical Biosensors?

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Electrochemical biosensors based on carbon nanomaterials have demonstrated a largely improved analytical performance. The success of the resulting biosensing platforms is highly connected with the efficient exfoliation and functionalization of the nanostructures. In this sense, we proposed "smart" strategies for non-covalent functionalization focused on the use of biomolecules that allow the development of building blocks for the rational construction of diverse bioanalytical platforms.

In this presentation we will discuss some typical examples of the use of biomolecules as functionalizing agents, enzymes like glucose oxidase and cytochrome c, lectins like concanavalin A, nucleic acids like calf-thymus double stranded DNA, and proteins like avidin, to develop electrochemical biosensors for the quantification of biomarkers of clinical relevance (BRCA-1-gen, SARS-CoV-2 nucleic acid, Immunoglobulin G, oxidative stress-related compounds, glucose) and pollutants, among others. The advantages of using rationally designed synthetic compounds able to mimic some properties of biomolecules as functionalization agents will also be discussed here.

In summary, the critical selection of biomolecules able to exfoliate the carbon nanostructures and give to them particular (bio)recognition properties represents an extremely advantageous alternative to obtain building-blocks of carbon nanostructure-biomolecule as specialized legos to be assembled for the development of custom made biosensors.

Keywords: Electrochemical biosensor; carbon nanostructures; biomarkers; biofunctionalization

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Recent Advances in Biosensors Based on Molecularly Imprinted Polymers and Nanozymes

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Molecularly imprinted polymers (MIPs) and enzymes have garnered significant attention in recent years due to their ability to mimic natural antibodies and enzymes, offering high selectivity and sensitivity in sensing applications. This presentation highlights recent advances in integrating MIPs with nanozymes to design innovative biomimetic sensors.

MIPs are synthetic polymers that contain specific cavities tailored to target molecules, created through molecular imprinting techniques. They offer several advantages over antibodies, including robustness, high stability, and low-cost preparation for the targeted analyte.

Nanozymes, synthetic nanomaterials that exhibit enzyme-like catalytic activities, have diverse applications across various fields. Their growing prominence is attributed to their superior performance in terms of activity, stability, tunable properties, and cost-effectiveness.

The synergy between molecularly imprinted polymers and nanozymes effectively mimics the functionality of natural enzymes, with nanozymes and MIPs acting as coenzymes and apoenzymes, respectively. For instance, decorating Fe3O4-Cu nanozymes with peroxidase-like catalytic activities using an appropriate MIP has been shown to improve the selectivity and detection limits for dopamine and L-DOPA.

The combined advantages of enzyme-like sensitivity and MIP selectivity have also been successfully applied to the colorimetric detection of quercetin. Furthermore, the non-specific adsorption phenomena often observed in MIP-based sensors were effectively suppressed by modifying the MIP surface with surfactants such as sodium dodecyl sulfate (SDS) and cetyltrimethylammonium bromide (CTAB).

Overall, the synergistic combination of MIPs and nanozymes presents a promising avenue for the design of artificial enzymes.

Generation of Nanomaterials via Spark Discharge: A Rapid, Environmentally Friendly, and Versatile Method for In-Situ Modification of Electrode Surfaces

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Spark discharge is emerging as one of the most promising physical methods for producing various types of nanomaterials, including metals, semiconductors, alloys, or carbon. This process occurs without the need for liquids, chemicals, or templates. It relies on the application of an electric field capable of generating an electric discharge when two conductors, connected to an external power supply, are brought close together (Fig. 1). In the context of electrochemical (bio)sensing applications, one of the conductors is the sensing (working) electrode, while the other acts as the source of modifying material, such as a metal, alloy, or carbon (referred to as the electrode tip).

During the dielectric breakdown process, free electrons and ions are produced from ionized molecules of air constituents. These particles then bombard the sparked electrodes. The heat generated by the flow of electricity leads to the formation of air plasma and vaporized particles from each electrode material at the closest points between the conductors. After a natural cooling process, the vaporized material solidifies and deposits onto the surface of the electrodes.

This technique offers a straightforward method for generating template-free (nano)materials of high purity. It allows for the in-situ modification of sensing electrodes, resulting in sensors with enhanced detection capabilities and a wide range of applications. Sparked (single or mixed) metal or graphite nanomaterial-modified electrodes can be prepared on demand, even on-site, within seconds, using a completely green and solution-free method that only requires the respective metal/alloy/carbon wire and a power supply. Data on the generation of bismuth [1,2], copper, nickel, and alloyed copper/nickel [3], tin [4], gold [5,6], iron [7], molybdenum [8], carbon [9-12], and cobalt [13] nanomaterials as well as on the analytical utility of the resulting sensors will be presented.

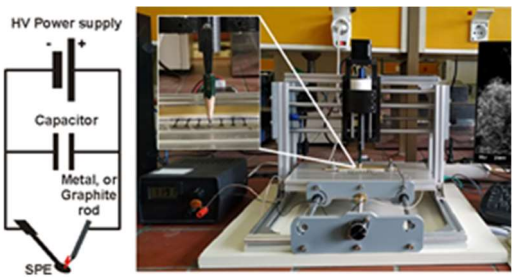

Fig.1. Setup for the in-situ tailoring of electrode surface with spark-generated (nano)materials

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Next-Generation Multiplexed Testing Systems: Advances in Paper-based and Electrochemical Biosensors for Enhanced Diagnostics

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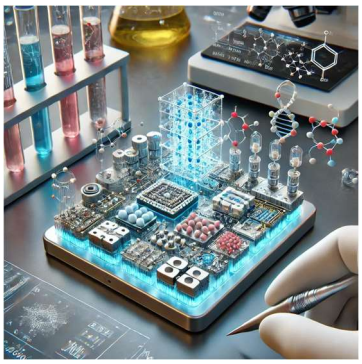
Multiplexed testing systems are at the forefront of diagnostic innovation, providing significant enhancements in speed, sensitivity, and specificity. This presentation will explore the latest advancements in these technologies. **Paper-based tests** have gained traction as cost-effective and accessible diagnostic tools, particularly in point-of-care settings [1, 6]. **Lateral flow assays** continue to be a cornerstone of rapid diagnostics, with recent advances focusing on enhancing multiplexing capabilities. For instance, the integration of nanocomposite materials in lateral flow assays are increased their sensitivity and enabling simultaneous detection of multiple targets such as pathogens. These innovations are crucial for applications requiring quick, accurate, and comprehensive diagnostics, such as in infectious disease outbreaks and environmental monitoring [2, 6]. As for **electrochemical biosensors**, these systems are increasingly recognized for their high sensitivity and real-time monitoring capabilities. The development of electrochemical biosensors that integrate advanced nanomaterials, such as carbon-based nanostructures and metal-organic frameworks cause an exceptional specificity in detecting low-abundance biomarkers and can be adapted for multiplexed formats [1, 3]. In conclusion, the integration of these multiplexed testing systems is paving the way for next-generation diagnostics. This lecture will provide an in-depth review of the current state and future directions of these technologies, highlighting their potential to revolutionize healthcare and environmental monitoring.



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Electrochemical Sensors Based on Conducting Polymer – Polypyrrole

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Synthesis of conducting polymers could be performed by different methods, namely by electrochemical [1], chemical [2] and even by several biochemical approaches [3,4]. The application of differently designed conducting polymer layers in biosensorics will be discussed [5,6]. Conducting polymer – polypyrrole – is well suitable for the entrapment of biomolecules, for this reason, this conducting polymer is very frequently applied in the design of affinity-sensors. Therefore, during this presentation significant attention will be payed towards conducting polymer based electrochemical affinity sensors [1]. Moreover, conducting polymers are suitable for the formation of molecularly imprinted polymers (MIPs), which can be used for the detection of various chemical compounds. Discussion will be based on our achievements in the synthesis of MIPs and application of MIPs in biosensors for detection of SARS-CoV-2 proteins. Electrochemical deposition of conducting polymer based MIP layers will be addressed [5]. The overoxidation of conducting polymer – polypyrrole – enables to increase analytical performance of MIPs-based on this polymer. Therefore, some attention will be focused on the overoxidation-based advancement of this polymer. Advantages of molecularly imprinted conducting polymers will be discussed [6]. Future trends and developments in the formation and application of conducting polymer based sensors will be addressed.

Keywords: Conducting polymers; Polypyrrole; Molecularly imprinted polymers; Biosensors.

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Brain-on-a-Chip Devices: Real-scale Sensorized Models

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The blood-brain barrier (BBB) is a highly selective and dynamic physiological barrier that separates the brain extracellular fluid from the bloodstream, regulating the exchange of nutrients and other molecules. However, it also poses a significant challenge for drug delivery to the central nervous system (CNS), the efficacy of which is limited by low BBB penetration.

In this context, several *in vitro* models have been introduced to provide a platform for studying the transport and permeability of drugs across the BBB, and our group realized the first real-scale microfluidic BBB system with microtubes inspired by the brain capillaries (Figures 1a-b). The architecture of the device was realized by using the two-photon polymerization (2pp) approach, an innovative real-3D microfabrication technique with unprecedented resolution. The device is interfaced with a microfluidic system imposing a liquid flow in the microtubes with a 1 mm/s speed, the same measured in the brain microcapillaries. Moreover, the system enables triple cell co-cultures, is reusable, and optically transparent [1].

As proof-of-concept, we measured the crossing of the nutlin-3a anticancer drug (Figure 1c); also, the nutlin-3a anticancer effects and selectivity were tested. To this aim, 3D multicellular organoids with malignant (human GFP-U87 glioblastoma cells) and non-malignant (human neural stem cells-derived neurons and the hCMEC/D3 human brain endothelial cells) cells have been self-assembled and incorporated in the device [2]. The findings showed a significantly higher cell death of malignant compared to non-malignant cells, demonstrating the nutlin-3a selectivity (Figure 1d).

As a further step, we are developing a sensorized microfluidic device able to mimic and monitor BBB maturation thanks to an integrated sensorization system. In this case, the microfluidic chip has been produced in polydimethylsiloxane (PDMS) through photolithography and soft lithography. The chip is bonded onto thin-film microelectrodes patterned by photolithography and lift-off on a glass substrate, allowing a real-time *in situ* evaluation of BBB integrity, maturation, and formation. The *in situ* measurement of the transendothelial resistance (TEER) is allowing the BBB integrity over formation and maturation.

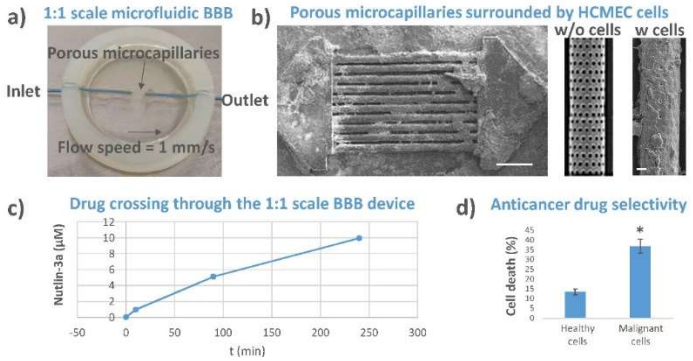

Figure 1. a-b) 1:1 scale microfluidic BBB model; c) Nutlin-3a crossing; d) Selective anticancer effect after BBB crossing. Scale bars: 250 and 10 μm.

Keywords: Blood-brain barrier; Microphysiological systems; Sensorized models

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Design of Microfluidic Chip Platforms for Pathogen Detection

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Culture technique is known as gold standard in the field of pathogen bacteria detection and this techique is also preferred in blood stream infection. Considering the disadvantages of blood culture technique, more accurate, selective and fast methods are highly demanded in this area. Before the planned analysis, bacteria enrichment in blood is a mandatory step in this type of analysis. Polymerase chain reaction and digital-droplet (ddPCR) techniques come into the prominence since they are fast and selective comparing to the gold standard. However, capturing bacteria, enrichment and nucleic acid extraction steps are required extra applications and equipment in the PCR applications. Accordingly, ddPCR applications are quite expensive systems even if they are fast. For this reason, a microfluidic chip platform which combines three different analysis was developed in our laboratory. Many microfluidic systems have been developed but most of them are insufficient in real sample applications and they are lack in adaptation to analysis in the related field. Especially, the paper microfluidics or microchip-based measurement is a novel approach and will be a powerful alternative to the expensive conventional techniques that necessitate the consumption of excess amount of sample and materials.
The present study aims to find out the most proper bioactive chip preparation method to develop for the quantitative determination of bacteria. In this respect, our analysis platform does not depend on the commercial kits and DNA of bacteria was isolated on the chip. The capture and lysis of bacteria in the blood sample were performed in the first part of the chip and this approach is quite new in this area.

Here, we also offer new magnetic nanoparticles based high-throughput DNA extraction method for pathogen detection in microfluidic chip. For this purpose, first time polymer brush coated monodisperse magnetic nanoparticles were prepared with interface-mediated RAFT polymerization to be used in DNA extraction process. After synthesizing Fe_3O_4 nanoparticles, silica shell was coated on the magnetic nanoparticle core. Polymer brushes was immobilized on the amine functionalized silica layer using RAFT agent. Subsequently, the resulting particles with poly(vinylbenzyltrimethylammonium chloride) (PVBTAC) grafted were finalized through interface-mediated RAFT polymerization. The developed particle provided both the rapid extraction of DNA and high-yield DNA recovery without requiring extended incubation and elution time. The maximum adsorption capacity was determined as 238.1 µg/mg. About 90 % of the input DNA was recovered.

The design, preparation and surface modification of assay platforms could be useable for the detection of target bacteria from complex matrices. The optimization strategies and the analytical performance of the chip-based assays will be presented.

Keywords: Pathogen bacteria; RAFT polymerization; DNA; microfluidic chip

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Microneedle Array-Based Smart Patches for Multiplexed Monitoring and Therapy of Chronic Wounds

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Topical chronic wound (CWO) dressings offer personalized management but have limited efficacy in sensing and delivering therapeutics due to their reliance on external wound exudate rather than the transdermal wound bed. Herein, we introduce a high-performance hydrogel-forming microneedles (HFMNs)-based transdermal dressing system for the first time that uses a highly conductive, biocompatible, and minimally invasive replaceable hydrogel-based microneedle array to monitor the physiological conditions of the transdermal wound ISF and perform intelligent therapy because of the hydrogel's antibacterial and antimicrobial properties. Compared to previously reported wearable sensors that rely on external wound bed exudate, theranostics at transdermal interstitial fluid (ISF) can provide more comprehensive and customized information for effective chronic wound management. The HFMNs is made of polyvinyl alcohol, a biocompatible and swellable polymer, and chitosan, a crosslinking agent. Conductive nanofillers, such as MXene (Ti3C2Tx) nanosheets, are added to the mixture to aid in the development of 3D polymer hydrogel networks by hydrogen bonding. The antimicrobial activity of the surface functional groups on MXene contributes significantly to the improvement of CWO healing and the enhancement of mechanical stability in hydrogels. Additionally, through the laserinduced phase separation of PEDOT:PSS/GO, we develop an innovative digital patterning method that is both biocompatible and capable of producing an highly conductive array of water-stable HFMNs. The laser-scribed phase separation (LSPS) significantly improved electrical conductivity and aqueous stability by virtue of the connected and enlarged PEDOT -rich regions. This theranostic approach establishes a correlation between exudate and wound-affected ISF, thereby facilitating the commercialization of the implantable dressing systems.

Keywords: Conductive hydrogel-forming microneedles (HFMNs) array; Laser-scribed phase separation; Chronic wounds; Diagnostics and therapy.

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Self-Assembled Brain Tumor-on-a-Chip: Implementation, Sensorization, and Drug Screening

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The development of highly predictive *in vitro* models for brain cancer is critical for advancing drug discovery and therapeutic testing, addressing the limitations of current preclinical approaches. We present a novel self-assembled brain tumor-on-a-chip platform designed to replicate the complex microenvironment of glioblastoma (GBM) for accurate drug screening.

Our approach involves two-photon polymerization to fabricate non-degradable, 3D prismatic-shaped scaffolds that support the co-culture of 3D glioma cells with nonmalignant brain cells and a real-scale blood-brain barrier (BBB) microfluidic system [1,2]. Using our patented method [3], the magnetic self-assembly enabled precise 3D co-culture formation without the drawbacks of traditional magnetic nanoparticles, which can interfere with cellular processes. This platform enabled the detailed study of cellular interactions, drug delivery across the BBB, and the therapeutic efficacy of anticancer agents, specifically nutlin-3a.

To enhance the functionality of our tumor-on-a-chip system, we have integrated electric sensorization within the 3D scaffolds, enabling real-time monitoring of tumor dynamics and drug effects [4]. Furthermore, the automated two-photon lithography process ensured the reproducibility of scaffold fabrication, overcoming challenges related to optical interfaces on electrodes. By performing impedance measurements through glioblastoma spheroids, we demonstrated the capability to provide real-time data on cell growth, spheroid formation, and hypoxic core formation. Moreover, the sensorized device allowed us to monitor spheroid responses to drug treatments. Our findings demonstrate that this sensorized brain tumor-on-a-chip platform offers a robust and versatile tool for high-throughput drug screening, providing valuable insights into the tumor microenvironment and advancing the development of effective brain cancer therapies. We are now focused on integrating our 3D scaffold-based platform with magnetic self-assembly technique to develop more sophisticated 3D co-culture systems. This integration aims to more accurately replicate the tumor microenvironment and enable detailed studies of drug treatment responses in advanced tumor models.

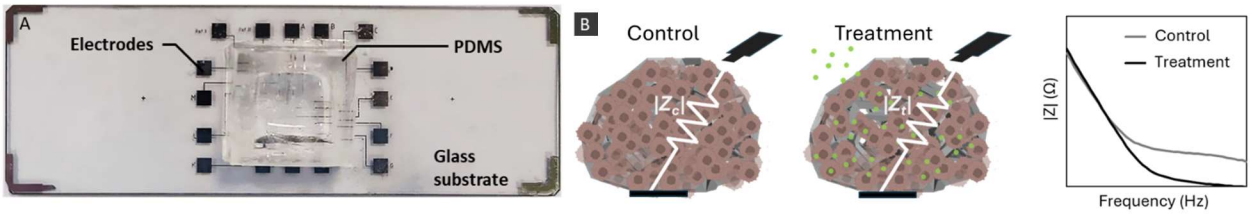

Figure 1. A) Sensorized device for multiplexed tumor spheroid monitoring. B) Working principle of the electric impedance monitoring of a glioblastoma spheroid treated with drug.

Keywords: Tumor-on-a-chip; 3D Co-Culture; Electrode Impedance; Drug Screening Device.

Acknowledgements
We acknowledge the financial support by ERC PoC (BiSCUIT; ID 101146025) and by the Marie Sklodowska-Curie Actions program (Theratools; ID 101073404).

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Nanophotonics for the Next Generation of Biosensors

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Nanophotonic phenomena are crucial to advance the state of the art of biosensors in terms of portability, miniaturization, sensitivity and user-friendliness, among other technological aspects [1]. In this invited talk, we will discuss several simple, yet powerful, (bio)analytical platforms based on nanophotonics with applications at the point of care, [2, 3] as well as in wearable devices [4-7] and in vitro diagnostics [8-10].

Keywords: nanoplasmonics; surface enhanced Raman spectroscopy; paper-based devices; graphene oxide

Acknowledgements
E.M.-N. acknowledges financial support from CONAHCYT (Mexico, grant no. 376135) and DGAPA-UNAM (Grant: PAPIIT-IT100124).

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Smart Optical Sensors for eDiagnostics and eMonitoring

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Integrating optical/photonic sensing bioplatforms with Internet of Things (IoT)-based digital technologies for application in wearables and (bio)sensors technology, aiming at early diagnosis and therapeutic monitoring of diseases/disorders at the point-of-care, has recently witnessed unprecedented growth [1]. Herein, an overview will be provided to highlight the importance and necessity of developing novel smart optical (bio)sensing devices for eDiagnostics and eMonitoring applications. Our current research on the development of smart wearable optical (bio)sensors, which enable non-invasive sensing of biomarkers in sweat, saliva, and interstitial fluid, with the aim of addressing unmet diagnostic demands in the era of digital health/Healthcare 4.0, will also be presented [2-6].

Keywords: Smart sensors, wearable sensors, neonatal point-of-care testing, tattoo sensors

Acknowledgements

I gratefully acknowledge supports from the Chemistry & Chemical Engineering Research Centre of Iran (Tehran, Iran), Iran Nanotechnology Innovation Council (INIC), and Iran's National Elites Foundation. I would like also to thank to the Alexander von Humboldt-Stiftung/Foundation for support under the Georg Forster Research Fellowship Programme.

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Paper-Based Opportunities in Sensors Development

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Despite substantial advances in sensing technologies, the development, preparation, and use of self-testing devices is still confined to specialist laboratories and users. Decentralized analytical devices will enormously impact daily lives, enabling people to analyze diverse clinical, environmental, and food samples, evaluate them and make predictions to improve quality of life, particularly in remote, resource-scarce areas. In recent years, paper-based analytical tools have attracted a great deal of attention; the well-known properties of paper, such as abundance, affordability, lightness, and biodegradability, combined with features of printed electrochemical sensors, have enabled the development of sustainable devices that drive (bio)sensors beyond the state of the art. Their blindness toward colored/turbid matrices (i.e., blood, soil), their portability, and the capacity of paper to autonomously filter/purge/react with target species make such devices powerful in establishing point-of-need tools for use by non-specialists. Depending on analytical requisites, different types of paper (filter, office) and configurations (1D, 2D, 3D) can be adopted. A wide overview regarding application ranging from nucleic acids to heavy metals, through pesticides detection will be provided, with the aim in showing the potentialities of paper-based electrochemical biosensors for improving society involvement in monitoring.

In addition, a novel approach for pre-concentration is reported. The use of a disposable paper-based architectures and origami, opportunely configured, represents the first examples of horizontal and vertical pre-concentrations. It highlights the suitability of producing a novel electroanalytical platform that does not require expertise-required tasks.

The talk is aimed to provide general basis regarding the development of smart electrochemical and optical strips for multiple applications. However, it should be noted that the term “paper” is too general: chromatographic paper, office paper and nanocellulose are only some of the paper-based substrates that can be exploited. The main question from non-experts is: which kind of support should I use? The best answer is “it depends”! Answers depend on the application and the analytical need.

Figure 1. All the possibilities for paper-based diagnostics [1]

Keywords: Paper-based; screen-printed electrodes; point-of-care; origami

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Laser-Induced Porous Graphene Electrodes for (Bio)Sensing

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The development of highly sensitive and selective sensors for detecting ions, pharmaceuticals, and toxins is vital for both environmental and health monitoring. This presentation highlights the potential of laser-induced graphene (LIG) as an advanced material for sensing and biosensing applications, with a focus on detecting heavy metal cations, nitrite, paracetamol, diclofenac, kanamycin, and aflatoxin B1. LIG, produced through direct laser writing, boasts a high surface area and excellent electrical conductivity, making it an optimal substrate for electrochemical sensing. The surface of LIG electrodes was further enhanced with nanomaterials and conductive polymers to boost their kinetic properties, increase the electrochemical surface area, or modified with aptamers specifically targeting kanamycin and aflatoxin B1.

Through the use of LIG-based electrodes modified with nanomaterials and/or aptamers, we developed various sensors and biosensors for detecting target analytes via electrochemical techniques such as square-wave anodic stripping voltammetry, square-wave voltammetry, and redox capacitance spectroscopy [1-2]. These electrodes exhibited strong sensing performance, with wide concentration ranges and low detection limits that meet WHO standards for maximum residue levels of contaminants in food and beverages.

In addition to their excellent sensing capabilities, laser-induced graphene electrodes are easy to produce, cost-effective, and readily adaptable for the detection of multiple key analytes, positioning them as a versatile solution for environmental and health monitoring.

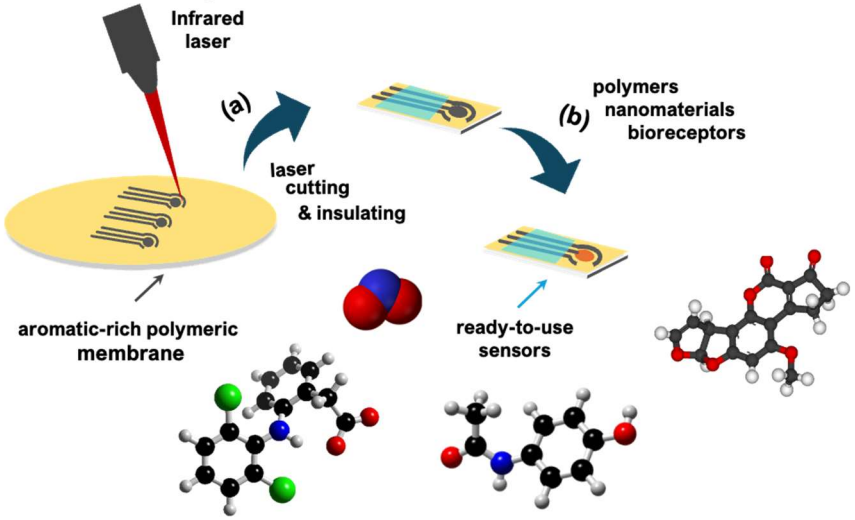

Figure 1. Schematic representation of the laser-induced electrodes preparation and their use for (bio)chemical sensing

Keywords: Graphene; Pharmaceuticals; Food safety; Environment

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Micro/Nanoscale Marvels Spanning From Sublime Minutiae To Intricate Designs

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The future of biology and medicine is poised at the intersection of engineering, chemistry, nanotechnology, and materials science. Notably, the realms of micro/nano-scale technologies and biomedical engineering have undergone remarkable growth and advancement in the past decade. The integration of cutting-edge technologies at the micro- and nano-scale—termed as "disruptive innovation," presents tremendous opportunities to address unmet needs and overcome key challenges in the fields of biology and medicine. In this talk, Dr. Fatih Inci explores state-of-the-art micro- and nano-scale technologies as precise solutions to improve human health and beyond. In this context, the platforms developed in his lab manipulate biomolecules, cells, cell dusts (extracellular vesicles: EVs), and pathogens in small volumes. Among biomarkers focused on by his team, EVs emerge as crucial carriers of information in cellular communication. Initially perceived as artifacts or cell debris, EVs are now recognized for their essential roles in the development and propagation of various diseases, as well as taking serious roles in disease diagnosis and therapeutics in precision health. However, isolating these nano-sized entities in a size-dependent manner presents a significant challenge in EV research. Conventional methods are often costly, prone to the loss of differently sized EVs or susceptible to contamination, thereby compromising the quality of subsequent investigations. His team's approach harmonizes microfluidics and biosensing strategies to isolate and identify EVs from clinically relevant specimens. This development establishes a diagnostic and screening scheme for point-of-care settings, enabling individuals to easily self-monitor their health status for precision health applications. Detecting these minuscule yet impactful EV markers represent not only a game-changer in medicine, but also opens up new avenues for precision health and clinical management.

Keywords: Extracellular vesicles, microfluidics, metamaterial sensor

Acknowledgements
Dr. Fatih Inci gratefully acknowledges the support from the Scientific and Technological Research Council of Turkey (TÜBİTAK) 2232 International Fellowship for Outstanding Researchers (Project No: 118C254), Outstanding Young Scientists Award (GEBİP) from Turkish Academy of Sciences, and Young Scientist Awards Program (BAGEP) form Science Academy.

Multi-Parametric Surface Plasmon Resonance: Advanced Measurement Principle for Biosensing Applications

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Biosensing has seen significant advancements in recent years, with surface plasmon resonance (SPR) established as one of the key technologies in the field. However, traditional SPR methods often face limitations in the range of sample types that can be effectively measured. This talk will explore the evolving landscape of SPR, with a particular focus on the multi-parametric approach that significantly enhances measurement capabilities for biosensing applications, including the integration of electrochemical analysis.

Multi-parametric surface plasmon resonance (MP-SPR) represents a next-generation technique that utilizes complete SPR curve measurement. By simultaneously analyzing parameters such as layer refractive index, thickness, and molecular interactions, MP-SPR provides a comprehensive, high-resolution profile of biological processes [1]. This advanced measurement principle accommodates a wide range of samples, from proteins to nanoparticles, and live cells, including complex real-world samples like milk, serum, and saliva. The integration of electrochemical analysis further broadens the scope and versatility of MP-SPR, making it an exceptionally powerful tool for diverse applications in biosensing.

In this presentation, I will demonstrate how MP-SPR, addresses the challenges of complex biosensing environments through various case studies and experimental data. Ultimately, this talk aims to provide a deeper understanding of the potential and practical implications of MP-SPR in advancing biosensing technologies.

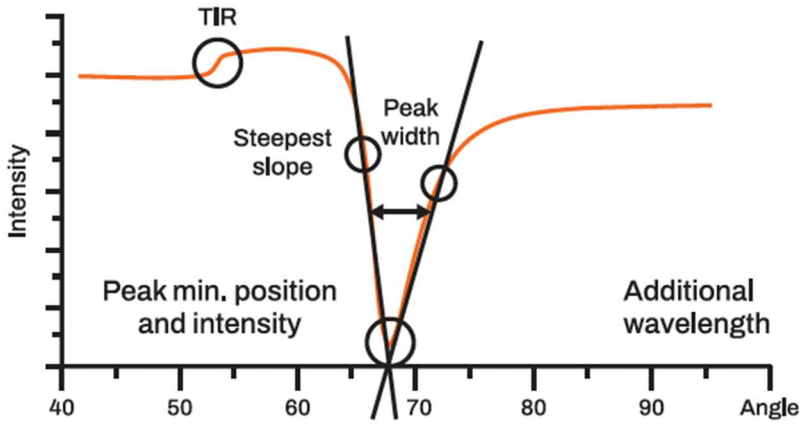

Figure 1. Visualizing the Power of Multi-Parametric SPR: A complete SPR curve enabling the advanced capabilities of MP-SPR in diverse biosensing applications.

Keywords: Molecular Interactions, Layer Properties, Electrochemistry, Multi-Parametric Analysis

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6th International Congress on Biosensors

ORAL PRESENTATIONS

Measuring Setup for Body Fluids Evaluation

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The present research paper aims to develop several innovative nanomaterials capable to improve the active surface for sensing applications. In this case the sensors are screen printed electrodes – (SPE) having exceptional electrochemical, optical and mechanical properties and a very good selectivity. The goal is to develop a flexible, wearable multiplex patch for rapid and efficient health status screening. The outcomes are related to a low cost, rapid and efficient evaluation system capable for real-time monitoring of health/food quality through the development of a new wearable/portable device for detection of contaminants/pathogens.

The most important aspect is to prepare the SPE sensors for several analytes and to ensure the selectivity and sensitivity of each working electrode (WE). When the health is the subject of evaluation there are several important indicators like lactate, glucose, cortisol, chloride and pH. For real-time monitoring it is mandatory to perform simultaneous electrochemical detection having a working electrode WE sensitive to each indicator and to provide a portable multichannel voltammetric measurement solution. Our approach is to use a multiplexed measuring solution for general indicator evaluation and for real-time evaluation to use a low cost multichannel device for simultaneous evaluation. The integration of the entire measuring system is performed by an instrumentation software capable to manage the opto-electrochemical system and all the external accessories that make part of the conditioning module (micropumps or microvalves).

Achievements of this work are related to multi-sensor flexible patch, the consolidated measuring system and the adaptability to other applications beside health or food quality.

In conclusion, the actual stage of development is based on very reliable SPE sensor capable to detect analytes like cortisol, glucose, lactate, chloride and pH. The sensors are mounted in a setup capable to extract sweat from the subject during an intense physical activity like body building, aerobic or kinetotherapeutic gymnastics. Real-time measuring configuration is based on several electrochemical microcontrollers integrated by an applicative software oriented to the health evaluation. For food quality evaluation we use other functionalized SPE electrodes and another part of the applicative software panel.

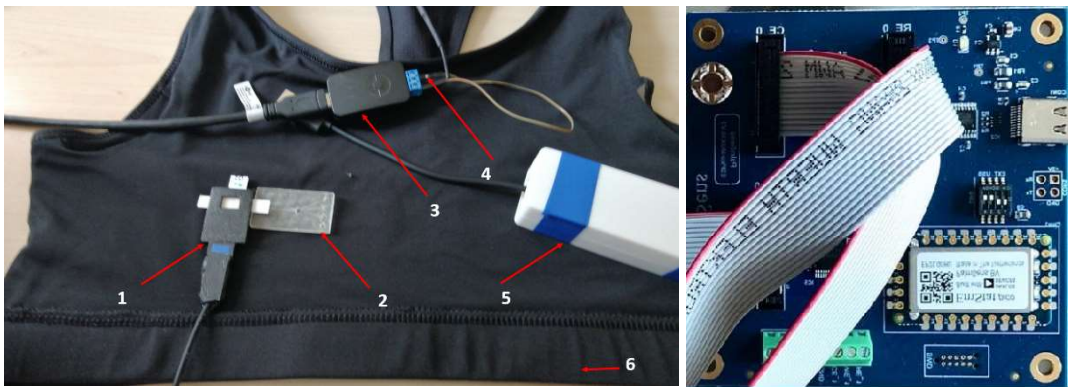

Figure 1. Initial setup for body sweat evaluation

Keywords: sensors; electrochemistry; devices; voltammetry

Acknowledgements
This work was supported by a grant of the Romanian Ministry of Research, Innovation and Digitization, CNCS/CCCDI – UEFISCDI, project COFUND-M-ERANET-3-FULSENS-GEL, contract no.318/2022 within PNCDI III.

Design of an Electrochemical Impedance Spectroscopy Instrument for Ingestible Biosensors

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In this work, the development of a novel, compact electrochemical impedance spectroscopy (EIS) instrument designed for ingestible sensors is presented. The device aims to provide reliable and accurate impedance measurements within the frequency range of up to 100 kHz, making it suitable for various biosensing applications. To validate the performance of our instrument, we conducted a series of comparative tests against commercial benchtop instruments. The results demonstrated that our device achieves similar performance metrics, confirming its potential as a viable alternative to larger, more cumbersome equipment. This advancement in miniaturized EIS technology promises significant implications for the future of ingestible sensors, offering portability and ease of use without compromising accuracy [1]. The size of the instrument was kept at 20x33 mm^2 because of practical reasons but it can be shrunk to 19x7.9 mm^2. It costs around £30.

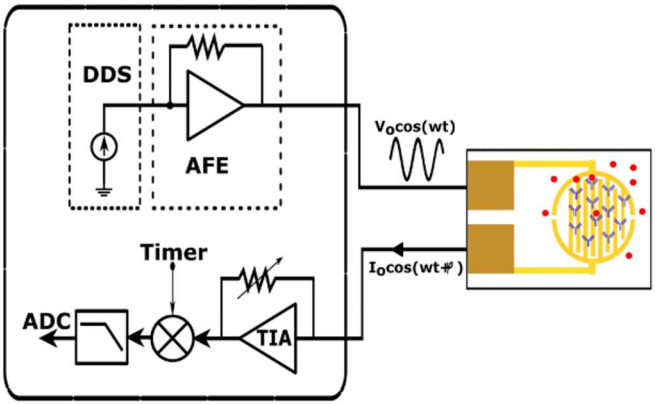

Figure 1. Schematic of the instrument

Keywords: Ingestible sensors; electrochemical impedance spectroscopy; immunosensors;

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Regeneration of Screen-Printed Gold Electrodes by Air Plasma Cleaning

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Screen-printed gold electrodes (SPGEs) are commonly used to develop electrochemical biosensors [1]. The development process of biosensors involves rigorous experimental trials. Due to the single-use nature of SPGEs, a considerable quantity may be consumed during experimentation, particularly when determining optimal conditions or in the case of failed experiments [2]. Disposing of used SPGEs and purchasing new ones is not a sustainable approach. To address this challenge, a plasma (ionized gas) cleaning technique is proposed to effectively regenerate of SPGEs. In this technique, an inductively coupled air plasma (30 Watt at 0.7 Torr) is used to eliminate the pre-immobilized aptamers and proteins [3]. The effect of plasma cleaning was studied by electrochemical impedance spectroscopy (EIS), X-ray photoelectron spectroscopy (XPS) and contact angle (CA) measurements. This plasma cleaning process can simultaneously clean multiple electrodes within a brief ten-minute timeframe. It is environmentally friendly, does not require any toxic chemical treatments, and preserves the electrochemical performance of SPGEs. Moreover, the regenerated SPGEs can be reused for chemisorption of thiolated aptamers with enhanced sensitivity for target detection. A thiolated aptamer against thrombin (5 µM) was tethered on the regenerated SPGE and found to increase charge transfer resistance (Rct) by ≈ 6.8 kΩ. Furthermore, incubating thrombin (50 nM) with the regenerated aptasensor increased the Rct by ≈ 37 kΩ due to the strong aptamer-thrombin binding affinity.

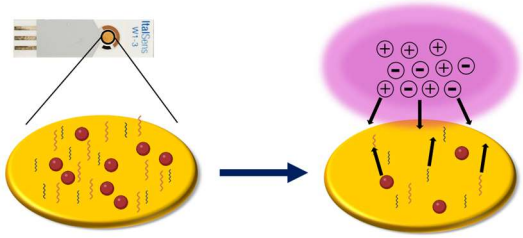

Figure 1. Air plasma treatment of SPGE effectively removes surface contamination

Table 1. Charge transfer resistance (Rct), Contact Angle (CA) and atomic percentage analysis results from XPS of SPGE Significant reduction in surface contamination is evidenced by the decrease in Rct (from ≈ 8340 to ≈ 963 ohms) and surface nitrogen atomic percentage (N%) (from ≈ 7.3% to 0.6%) with an increase in hydrophilicity (from ≈ 76° to ≈ 33°).

SPGE samples	Rct (Ω)	CA°	Au%	C%	O%	N%
Contaminated	8340 ± 13%	76 ± 10%	25.5 ± 2%	48.3 ± 2%	18.9 ± 1%	7.3 ± 6%
Plasma cleaned	963 ± 3%	33 ± 7%	26.1 ± 3%	46.2 ±1%	27.1 ± 2%	0.6 ± 20%
New untreated	1234 ± 13%	101 ± 3%	21.4 ± 4%	56.1 ± 4%	21.4 ± 5%	1.1 ± 24%

Keywords: Aptasensor; Plasma; Surface Treatment; Gold electrode

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Self-Powered Photoelectrochemical Immunosensor Using MIL-88A Derived NiFe LDH Double Shell Nanocages with TiO_2/PCN Heterostructure for the hCG Detection

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Human chorionic gonadotropin (hCG) is a vital marker for pregnancy and a significant biomarker for diseases related to the reproductive system. It is also widely used for treating male infertility and initiating ovulation in women [1]. However, elevated levels of hCG in the human body can lead to the development of cancerous tumors such as choriocarcinoma, prostate tumors, and trophoblastic, testicular, and gestational tumors. Modern optical electronics and biological systems can be integrated to create advanced bioelectronic detection with great potential. As an emerging detection technique, self-powered photoelectrochemical (PEC) biosensors offer several advantages: they do not require an external power supply, are easy to miniaturize, and are cost-effective [2]. Notably, self-powered PEC biosensors can operate at zero bias voltage without an external power source, enhance anti-interference activity, and have become an emerging sensing technique. Consequently, these implantable or portable devices have gained prominence in biological analysis. In this study, a composite material consisting of MIL-88A-derived NiFe LDH double shell nanocages with titanium dioxide (TiO_2)/phosphorus-doped graphitic carbon nitride (PCN) was synthesized. The resulting Ni-Fe LDH DSNCs/TiO_2/PCN was used to modify a fluorine-doped tin oxide (FTO) substrate for effective hCG monitoring. By incorporating Ni-Fe LDH DSNCs, TiO_2, and PCN in the composite, the material exhibited visible-light absorption ability, low charge transfer resistance, good charge separation and transfer characteristics, high charge carrier mobility, and the highest photocurrent density at zero-bias voltage (0 V vs Ag/AgCl). This technique, which utilizes a separate excitation source (light) and detection signal (electrical signal), offers high detection sensitivity and reduced background interference, providing a considerable opportunity for advanced analysis of hCG. The amperometric response of the resulting immunosensor showed a linear relationship with hCG concentration in the range of 0.0001-100 ng/mL, with the detection limit (LOD) determined to be 26.1 fg/mL. The fabricated immunosensor offers high stability, selectivity, and reproducibility. Moreover, the real-time detection of hCG was demonstrated in urine samples.

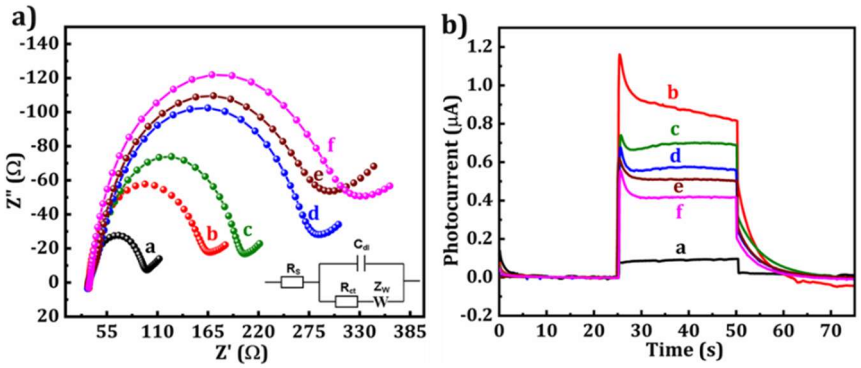

Figure 1. (a) EIS and (b) PEC signals of a-FTO, b-Ni-Fe LDH DSNCs/TiO_2/PCN/FTO, c-Glut-CS-Ni-Fe LDH DSNCs/TiO_2/PCN/FTO, d-Ab-hCG/Glut/CS-Ni-Fe LDH DSNCs/TiO_2/PCN/FTO, e-BSA/Ab-hCG/Glut/CS-Ni-Fe LDH DSNCs/TiO_2/PCN/FTO, f-hCG/ BSA/Ab-hCG/Glut/CS-Ni-Fe LDH DSNCs/TiO_2/PCN/FTO.

Keywords: Human chorionic gonadotropin; Ni-Fe LDH DSNCs; PEC Immunosensor; Amperometry.

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A Disposable Label-Free Electrochemical SMRP Immunosensor

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Soluble mesothelin-related protein (SMRP) is highly increased in the blood of patients with ovarian tumors [1]. It has also been reported to be an important biomarker for monitoring the treatment of lung metastatic tumors [2]. Therefore, sensitive detection of SMRP biomarkers is of great importance, especially in the diagnosis of tumors metastasized to the lung and ovaries. In this study, a label-free electrochemical SMRP immunosensor was prepared for sensitive, low-cost, and rapid detection of SMRP using hand-made disposable electrodes. Firstly, hand-made electrodes were prepared using the screen-printing method and then, the surface of the working electrode was deposited with gold nanoparticles (AuNP) using the CV method. To prepare the label-free SMRP immunosensor, AuNP-modified hand-made electrodes were modified with 6-mercapto hexanoic acid (6-MHA), EDC-NHS, anti-SMRP, BSA, and SMRP, respectively. The electrochemical characterizations of the prepared single-use SMRP immunosensors were performed by CV, DPV, and EIS. The preparation steps of label-free SMRP immunosensors are given in Figure 1. Optimizations of antibody concentration, antibody, and antigen incubation time of the SMRP immunosensors were performed using DPV and EIS techniques. Then, analytical characterizations (linear range, detection limit, repeatability, and selectivity test) were performed at the optimum conditions by DPV and EIS methods. The developed disposable SMRP immunosensors are fast and practical candidates for use in point-of-care testing.

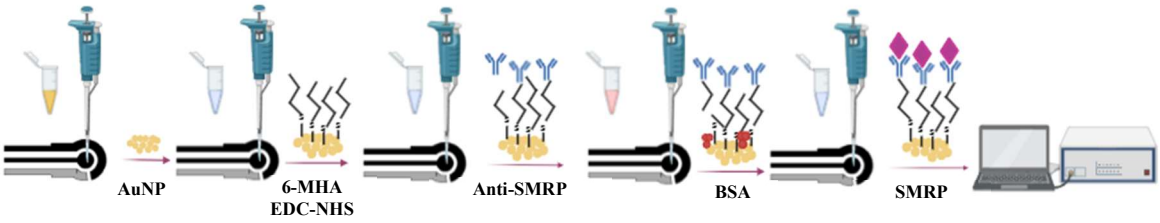

Figure 1. The fabrication stage of SMRP immunosensor

Keywords: SMRP, immunosensor, hand-made electrode

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Electrochemical DNA Nanobiosensors Containing Carbon Nanotubes or Graphene Oxide Derivatives and Examples of Their Current Applications for Genetic Disease/Drug-DNA Interaction Analysis

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The first commercial biosensor developed for blood glucose measurement was released in the 1970s, and many "biosensors" with different features have been developed since then. This field of research remains popular in the world. In this regard, as stated in some global biosensor reports published in the last five years and containing numerous literature and industry statistics, it is predicted that portable/hand-held or wearable biosensors will be preferred in many areas such as medicine, agriculture, food, etc. in the very near future and that these technologies will even be quite valuable.

On the other hand, biosensors using nanomaterials produced using nanotechnology still maintain their important place in the scientific world today and play a key role in many research projects. Among nanoparticles, carbon-containing species are considered very valuable, especially in electrochemical biosensor designs.

In this context, some current electrochemical biosensors designed in our laboratory for the purpose of genetic disease/drug-DNA interaction analysis, containing carbon nanotubes (CNT) and/or graphene oxide (GO) used to increase performance in electrochemical analyses, are mentioned here by evaluating their relevant design schemes and analysis performances.

Keywords: Electrochemical Biosensors; carbon nanotubes (CNT); graphene oxide (GO); Genetic Disease/Drug-DNA Interaction Analysis.

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A 3D Mini Electrochemical Cell Fabrication and Impedimetric Detection of CEA Using the Pencil Graphite Three-Electrode System

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3D printing, also known as additive manufacturing, is a process that fabricates three-dimensional objects from digital files by adding layers of material sequentially. Over the past decade, technological advancements like fused filament fabrication (FFF) have made 3D printing more affordable and widely accessible [1]. This technology has emerged as a hot topic subject across various research areas, especially for biosensors in many applications [2,3]. The biosensor we developed can be mass-produced at a very low cost due to the three-electrode system used. It is an important candidate for point-of-care applications due to its low cost and the fact that it uses a few hundred microliters of electrolyte. The three-electrode system in the electrochemical cell consists entirely of pencil graphite electrodes (PGEs). The reference electrode was obtained by applying conductive silver paste to the surface of the PGE, and the counter and working electrode were prepared by gold nanoparticles (AuNPs) electrochemical deposition on the PGE surface. The AuNPs/PGE electrode was treated with 11-mercaptoundecanoic acid, Anti-CEA, and CEA solutions. EIS analysis result demonstrated a significant change in the electron-transfer resistance (R_{CT}) to various concentrations of CEA in $Fe(CN)_6^{3-/4-}$ probe solution. In addition, the optimization of the developed sensor's parameters, stability, and selectivity was evaluated through R_{CT}. Consequently, the use of one of the important label-free techniques such as electrochemical impedance spectroscopy makes this sensor more privileged [4].

Keywords: CEA sensor; 3D cell; EIS.

Acknowledgements
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Point-of-Care Testing: A Disposable Electrochemical HE4 Immunosensor

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Point-of-care testing (POCT) is critical in healthcare, particularly in diagnosis, treatment, monitoring, and economics. Disposable electrodes are frequently preferred because they are fast, practical, and easy to use. Combining their portability and use outside the laboratory (quality control, environmental monitoring, etc.) with POCT devices in areas where resources are limited can ensure rapid and low-cost analysis [1]. The use of POCT devices in biosensor studies provides rapid results. Human epididymal protein 4 (HE4) levels are a biomarker detectable in blood in the early stages of ovarian cancer. It is important to measure low levels of HE4 quickly and practically in the early diagnosis of the disease.

In this study, label-free electrochemical HE4 immunosensors were prepared for sensitive, low-cost, and rapid detection of HE4 in blood serum samples. Firstly, screen-printed carbon electrodes (SPCE) were modified with Mxene-COOH and gold nanoparticles (AuNP). Morphological characterization of SPCE/MXene-COOH/AuNP by SEM, and chemical characterization by XRD and FT-IR. To prepare label-free HE4 immunosensors, SPCE/MXene-COOH/AuNP were modified with 6-mercapto hexanoic acid (6-MHA), EDC-NHS, Anti-HE4, BSA, and HE4, respectively. Electrochemical characterizations of the prepared HE4 immunosensors were performed by CV, DPV, and EIS. The fabrication steps of the label-free HE4 immunosensor are given in Figure 1. Optimization of experimental parameters (antibody concentration, antibody and antigen incubation times) and analytical characterizations (linear range, detection limit, reproducibility, and selectivity test) for HE4 immunosensors were performed by the portable electrochemical reader. Application and storage stability, selectivity, repeatability, regeneration, and real sample studies were also carried out. HE4 level in blood serum was measured directly at pM concentration with the developed HE4 immunosensors and portable electrochemical reader. The developed disposable HE4 immunosensors are fast and practical, suitable for use in point-of-care tests.

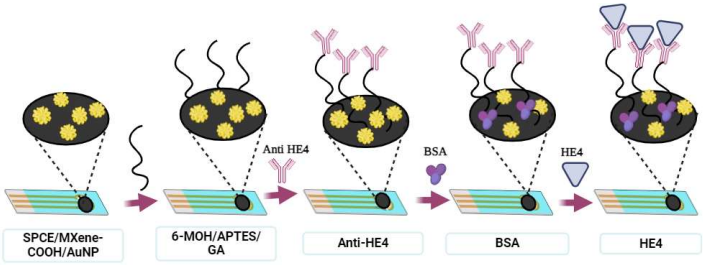

Figure 1. The fabrication stage of HE4 immunosensor

Keywords: HE4; POCT; MXene-COOH; AuNP

Acknowledgements
This study was supported by Çankırı Karatekin University Scientific Research Projects Coordinator (BAP) (Grant No: EY0211221D07), and the Scientific and Technological Research Institution of Turkey (TUBITAK) 1001 (project number:118R030) and 1002-A Fast Support Program (project number: 222Z121). Merve YILMAZ ÇILÇAR thanks the financial support from the Scientific and Technological Research Council of Turkey (TUBITAK) under the BIDEB/2211-A Ph.D. Scholarship Programs.

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Development of an Electrochemical Tyrosinase Biosensor Incorporating Selenium-Conjugated Polymer and Amine Functionalized Quantum Dots for Catechol Detection and Inhibition Applications

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In this work, an electrochemical biosensor was constructed by incorporating Tyrosinase into a unique three-component organoselenium-based random conjugated polymer matrix composed of [α-2-thienyl-ω-2-thienyl-poly[4,8-bis((2-ethylhexyl)oxy)benzo[1,2-b:4,5-b′]dithiophene-alt-(5,6-dimethoxybenzo[c][1,2,5]selenadia-zole5-(2-ethylhexyl) -4H-thieno[3,4-c]pyrrole-4,6(5H)dione)] (PSe) along with NH_2 functionalized quantum dots. Tyrosinase (Tyr, EC 1.14.18.1), a copper-containing metalloenzyme, facilitates the biosynthesis of melanin and other pigments by oxidizing tyrosine and is present in plant, bacterial, mammalian, and fungal tissues [1]. The enzymatic activity of Tyrosinase towards catechol, a well-established substrate, was optimized by adjusting the quantities of NH_2 functionalized quantum dots, conducting polymer, PSe, Tyrosinase, and the percentage of glutaraldehyde. The optimal conditions were achieved using 3 µL of PSe to immobilize 5 µL of Tyrosinase in conjunction with 2 µL of NH_2QDots. Under these optimized conditions, catechol detection was possible within a range of 0.1-88 µM, with a detection limit of 0.023 µM and a quantification limit of 0.07 µM. This study examined the inhibition of Tyr using rosmarinic acid derived from specific plants. The inhibitory effects of plants containing rosmarinic acid, specifically *Rosmarinus officinalis* and *Eryngium campestre*, were investigated using the newly developed electrochemical biosensor [2]. High-performance liquid chromatography (HPLC) analysis revealed significant levels of rosmarinic acid in both plants. The inhibitory effects were evaluated by measuring the current corresponding to the enzyme activity of the biosensor towards catechol in the presence and absence of the inhibitor. The inhibition conditions were optimized by determining the appropriate incubation time required for inhibition. The inhibitory potency, represented by the I50 value (the concentration at which 50% inhibition is observed), was calculated. The I50 values were found to be 17 µM for Rosmarinus officinalis and 21 µM for Eryngium campestre, indicating the effectiveness of these plants in inhibiting Tyrosinase activity.

Keywords: Biosensor; Catechol; Inhibition; Tyrosinase; Electrochemistry

Acknowledgements
Gulsu Keles and Sevinc Kurbanoglu acknowledges the support given by TÜBİTAK–2209-A.

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An Aptamer-molecularly Imprinted Polymer Electrochemical Sensor for Bacteria Detection in Water

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Pathogenic bacteria and the diseases they cause are a global problem. Accurate and rapid detection of bacteria is vital to prevent their exposure to humans and animals. Of particular importance is the detection of bacteria in drinking and bathing waters. Great progress has been made in this field with the use of biosensors. Molecularly imprinted polymers have gained broad interest because of their excellent properties over natural receptors such as being stable in a variety of conditions, inexpensive, biocompatible, and having long shelf life [1]. These properties make molecularly imprinted polymers an attractive candidate to be used in biosensors. On the other hand DNA aptamers can provide good affinity and selectivity towards the targets they were selected against.

We produced aptamer-molecularly imprinted polymer based electrochemical sensors by utilizing the properties of molecularly imprinted polymers coupled with the enhanced specificity offered by DNA aptamers. These 'apta-MIP' sensors were used for the detection of *Staphylococcus aureus* and *Escherichia coli* in both buffer and tap water. The experimental parameters for the fabrication of the sensors were optimized and detection of the bacteria was evaluated via non-Faradaic electrochemical impedance, i.e. by evaluating the capacitance of the system without the need for the addition of redox mediators.

The apta-MIP sensors showed good sensitivity and selectivity in terms of detection of *Staphylococcus aureus* and *Escherichia coli*, with a dynamic range from 1 to 10^8 cfu/ml. The results pave the way for point-of-use sensors enabling the rapid detection of pathogenic bacteria in water.

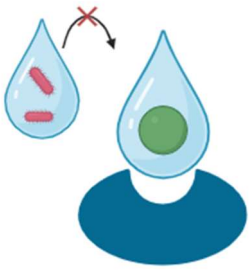

Figure 1. *Staphylococcus aureus* imprinted polymer for bacteria detection in water

Keywords: imprinting; aptamer; bacteria.

Acknowledgements
Meltem Agar funded by the Turkish Ministry of National Education, Republic of Türkiye.

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Developing Molecularly Imprinted Polymeric Nanoparticles and Iridium-based Optical Sensors for Amphetamine Type Stimulants

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Synthetic drugs known as amphetamine-type stimulants (ATSs) are a class of banned drugs all over the world. ATSs are placed near the topmost-used illicit drugs. Most of the recorded forensic cases worldwide of crime, violence, and attempted murder are directly related to ATSs. Hence, fast, cheap, and reliable detection of ATSs is still very important for public health and national security [1].

Iridium (III) complexes offer significantly higher ECL intensity compared to ruthenium (III) complexes about 70 times higher. This increased intensity translates to better analytical parameters and sensitivity [2]. Although they are soluble in organic solvents, their limited solubility in aquatic media has been addressed by modifying them with multi-walled carbon nanotubes (MWCNTs). These modified Ir (III) complexes are expected to exhibit high ECL sensitivity when investigated in biological samples [3]. A significantly high ECL result was obtained in the presence of 0.15 mg/mL MWCNT and 1 mg/mL Ir (III). However, in the presence of high MWCNT concentrations, the ECL signal was adversely affected and substantially decreased.

Therefore, MIP-NPs provide modern chemical sensor applications with more measurable properties. MIP-NP/MWCNT/Nafion-Ir/GC system in the project can determine concentrations of AMP in biological levels. Detection of AMP gives a chance to have a more detailed observation of how ATSs move in human body because of metabolic pathways and gives more exact estimation.

As the original value of the project, Ir (III) complexes with MWCNT modification were used in MIP-NP/ECL/co-reactant system in biological samples. This project has a high potential to be a lead study about usage of Ir (III) complexes in body fluids. Also, this project aims to develop ECL-based sensors and reliable, fast, and portable detection of amphetamine (AMP). Thus, commercial potential of the ECL systems was investigated and presented in detail.

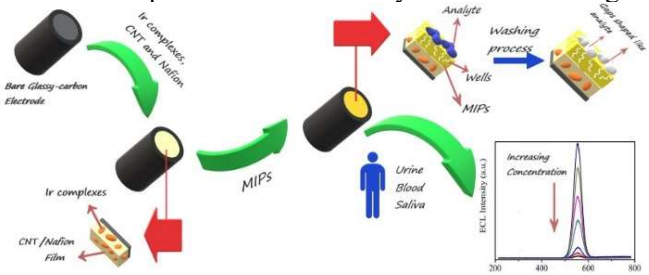

Figure 1. Schematic illustration of the optic sensor system.

Keywords: Molecularly imprinted polymer; Iridium complex; Multi walled carbon nano tubes, electrochemiluminescence; Amphetamine Types

Acknowledgments
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Coupling Plasmonic Metasurfaces with Fluorescence for Enhanced Detection of Microplastics in Real-samples

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Microplastics (MPs) could be detected with diverse analytical techniques as remnants of plastic products in different food and water sources at even hazardous concentrations [1]. Limitations of the existing MP detection strategies need to be improved from sensitivity and specificity aspects in order to prevent MP infiltration to the cellular level in all types of organisms [2]. In this work, we device a holistic strategy to detect MPs with picogram (pg)-level limit of detection (LOD) from polymethyl methacrylate (PMMA, 0.18 pg LOD) and polyethylene terephthalate (PET, 0.21 pg LOD) sources, from both spiked and real environmental samples. Our overall strategy includes a series of advanced techniques coming together to first, refine MPs from samples with a microfluidic ultrafiltration chip, then incorporating a quick-staining method with Nile Red to dye microplastics and enhanced analysis of microplastics on metasurface substrates, which are also previously used techniques in our studies [3,4]. Herein, we achieved an enhancement rate of 8.79-fold increase in the detection of MPs through our innovative workflow. This integrated strategy to refine MPs with microfluidic systems and metal-fluorescent enhancement of MP detection promises a pivotal advancement for MP detection studies in both spiked and real life samples.

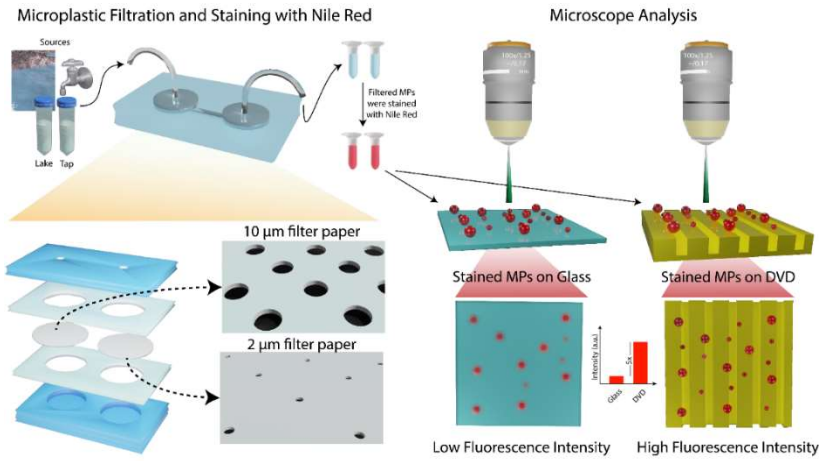

Figure 1. Illustration of workflow from microplastic filtration using 3D-printed microfluidic chip to microplastic analysis using metasurface substrates under microscope. Unpublished figure, Inci Lab, 2024.

Keywords: Microplastic, Plasmonic Sensor, Microfluidic Filtration

Acknowledgements
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Design of DNA-Inorganic Hybrid Based Signal Platform for GMO Detection with Personal Glucose Meter

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Many methods have been developed to detect nucleic acid (DNA, RNA) sequences, such as RT-PCR, rolling circle Amplification (RCA), DNA microarray, and Southern Blot. Although these methods provide sensitive and accurate results, they are time-consuming methods that require complex equipment, the supply of expensive chemicals and expert personnel. In this regard, the use of DNA-based biosensors appears as a powerful alternative for the development of fast, reliable, cheaper and easy-to-use biosensing platforms for the detection of various analytes. High analytical performance and lower detection limit (LOD) are among the most tremendous features in their development [1]. Another one, portability, could be provided by using personal glucose meters (PGM) from which signals can be obtained. For instance, reactions in which sucrose, whose enzymatic product is glucose, is hydrolyzed by the invertase enzyme can be detected with a personal glucose meter (PGM). Recently, various enzymes have been conjugated with DNA sequences to develop DNA-based biosensor. Carrier-free immobilization methods such as cross-linked enzyme aggregates (CLEAs) are becoming the center of interest since the attachment of enzymes used in biosensor design to various surfaces is disadvantageous in many respects. It is possible to easily separate biomolecules from the reaction medium by magnetite cross-linked enzyme aggregates (MCLEA) developed by adding magnetite nanoparticles to the system [2].

Based on all of above concept, this study aims to develop a new signaling platform designed with DNA-inorganic hybrid-based nanomaterials that will practically determine the permissible limit values of the genetically modified organism (GMO) as a model nucleic acid sequences by a PGM. Within the scope of this study, this is the first time, different from the literature, GMO was easily determined by using PGM with the developed signal platform (DIP), thanks to a unique design. For this purpose, firstly, cross-linked invertase aggregates were attached to magnetite nanoparticles (MCLIA). The DNA-inorganic hybrid-based signal platform (DIP) was designed by attaching the thiol-activated probe DNA, complementary to the selected target DNA (CaMV 35S promoter model sequence contained in GMO), to this functionalized structure. The detection of target DNA is based on the inhibition mechanism of Ag^+ on invertase enzyme at different rates in the presence of ssDNA (DIP includes prob DNA) and dsDNA (DIPH includes hybrid "prob + target" DNA). The analytical performance of DIP for GMO detection was tested by measuring glucose generated as a result of its interaction with sucrose solution by PGM, depending on the above mechanism. The components of the DIP structure have been characterized using different techniques.

The characterization results revealed that the magnetite in DIP was modified appropriately without affecting its superparamagnetic property and crystal structures, the enzyme and probe DNAs were successfully attached to this structure, hybridization occurred, and Ag^+ interacted with the structural components. MCLIA can be used 27 times for two months without losing its activity. It has been determined that DIP has a high probe DNA holding capacity ($1160^{\pm 17}$ ng) and can practically detect GMO with a detection limit of 47 ng. The developed DIP can also be used for different nucleotide sequence analyses.

Keywords: Personal glucose meter (PGM); DNA-inorganic hybrid-based signal platform; GMO detection,

Acknowledgements
This study was supported financially by the Scientific and Technological Research Council of Turkey (TUBITAK grant Number: 119Z380)

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Development of an Electrochemical Impedimetric Biosensor System through Selection of DNA Aptamers Targeting Parathyroid Hormone (PTH)

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This study introduces a novel aptamer-based electrochemical biosensor developed for real-time monitoring of parathyroid hormone (PTH) levels, specifically targeting intraoperative assessment in parathyroid surgery. It presents the first selection and characterization in literature of aptamers that bind to distinct segments of the PTH peptide. The biosensing platform's feasibility and efficacy are demonstrated through SELEX-based aptamer selection, aptamer-peptide interaction analysis, and biosensor fabrication. Aptamers derived from SELEX show high affinity to different PTH fragments, notably the PTH (53-84) aptamer displaying sensitive binding to the hormone's C terminus, facilitating precise PTH analysis. Electrochemical characterization reveals significant changes in impedance spectroscopy signals with varying PTH concentrations, confirming the biosensor's sensitivity and selectivity. Increasing charge transfer resistance (Rct) values at higher PTH concentrations validate its capability to detect PTH-induced structural changes. The biosensor exhibits excellent selectivity in serum interferents and maintains stability over a 45-day storage period, ensuring reliability for practical applications. In summary, this aptamer-based biosensor represents a pioneering tool for sensitive and selective PTH detection, applicable in biomedical research and clinical diagnostics, particularly for intraoperative PTH analysis in parathyroidectomy. Future research aims to enhance performance and expand application across healthcare settings.

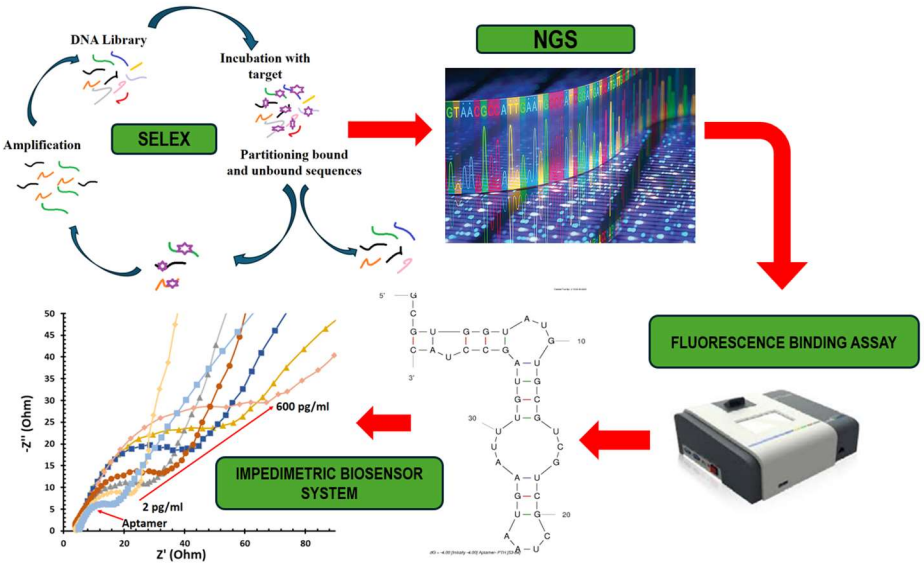

Figure 1. Overview of aptamer selection, characterization for PTH, and preparation steps for the electrochemical biosensor.

Keywords: Parathyroid hormone (PTH), SELEX, Aptamer, Impedimetric Biosensor, Electrochemical Detection

Acknowledgements
This study was supported by The Scientific and Technological Research Council of Turkey (TÜBİTAK) under the grant number of 121Z938.

Development of Electrochemical Sensor for the Detection of Chloropropanols that are Important for Food Safety

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Metal organic frameworks are one- or multi-dimensional structures formed by coordinating metal ions or groups with organic ligands. These materials are gaining increasing attention due to their large surface areas, smooth surfaces, and excellent stabilities [1]. Meanwhile, molecular imprinting polymer technique (MIP), known for its high selectivity, has become a preferred method in electrochemical sensors in recent years [2]. In this study, a molecularly imprinted polymer based Fe-MIL-88_BDC metal organic framework (MOF) modified electrochemical 3-chloropropane-1,2-diol (3-MCPD) sensor was developed. Commercial gold screen printed electrodes were modified with MOF structure. Then, a MIP layer was formed on the electrode surface via electropolymerization, by using aniline as a monomer and 3-MCPD as a template molecule. In order to improve the response of the prepared MIP based sensor, experimental parameters such as MOF amount, MIP layer thickness, template molecule/monomer ratio, elution time and rebinding time were optimized. by applying differential pulse voltammetry in the presence of $1x10^{-5}$ M 3-MCPD in pH 7.0 100 mM phosphate buffer in the range of -0.3 and 0.6 V. After that, analytical characteristic studies (limit of detection, limit of quantification, relative standard deviation, etc.) were performed. The specificity of the developed MOF-modified MIP based 3-MCPD electrochemical sensor was investigated in the presence of interference agents. The developed system was then adapted for the determination of 3-MCPD in various food samples. The real sample experiments were also validated by gas chromatography-mass spectrometry, which is described as the gold standard method for 3-MCPD analysis.

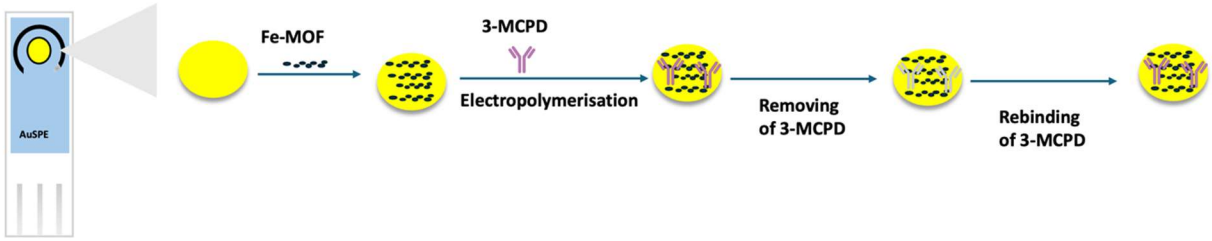

Figure 1. Schematic illustration of the preparation of MOF-modified MIP based electrochemical 3-MCPD sensor

Keywords: Fe-MIL-88_BDC metal organic framework**,** aniline molecular imprinting polymer, electrochemical sensor, food safety

Acknowledgements
The grant from TUBİTAK-3501 coded with project no: 122Z827 was gratefully acknowledged.

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A Label-Free Electrochemical FOLR1 Immunosensor Prepare Using a Hand-Made Disposable Electrode

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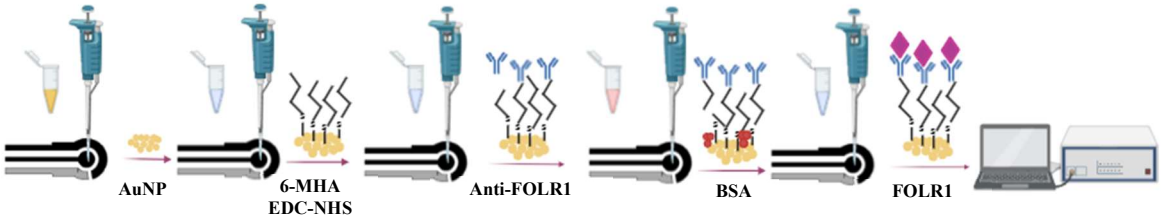
The folate receptor 1 (FOLR1) biomarker is overexpressed in various tumors such as ovarian cancer, non-small cell lung cancer, breast cancer, and kidney cancer [1]. Therefore, FOLR1 has been proposed as an ideal marker for the diagnosis of ovarian cancer [2]. FOLR1 biosensors in the literature are usually DNA-based. DNA-based biosensors are time-consuming and costly. Therefore, sensitive detection of FOLR1 biomarkers by label-free antibody-based biosensors is of great importance for the early detection of various cancers. In this study, label-free electrochemical FOLR1 immunosensors were prepared for sensitive, low-cost, and rapid detection of FOLR1 using hand-made electrodes. Firstly, hand-made electrodes were prepared using the screen-printing method. The surface of the working electrode was first deposited with gold nanoparticles (AuNP) using the CV method. To prepare label-free FOLR1 immunosensors, AuNP-modified hand-made electrodes were modified with 6-mercapto hexanoic acid (6-MHA), EDC-NHS, Anti-FOLR1, BSA, and FOLR1, respectively. Electrochemical characterizations of the prepared FOLR1 immunosensors were performed by CV, DPV, and EIS. The preparation steps of the label-free FOLR1 immunosensor are given in Figure 1. Optimization of experimental parameters (antibody concentration, antibody and antigen incubation times) and analytical characterizations (linear range, detection limit, repeatability, and selectivity test) for FOLR1 immunosensors were performed by DPV and EIS methods. The developed disposable FOLR1 immunosensors are fast and practical candidates for use in point-of-care testing.



Keywords: FOLR1, immunosensor, hand-made electrode

Acknowledgments: This study was supported by the Scientific and Technological Research Institution of Turkey (TUBITAK) 1001 (project number:122Z426). Ayşenur YILMAZ KABACA thanks the financial support from the Scientific and Technological Research Council of Turkey (TUBITAK) under the BIDEB/2211-A Ph.D. Scholarship Programs.

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3D-Printed Electrochemical Biosensor Applications for Clinical Analysis

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Three-dimensional (3D) printing technology is a simple, fast, low-cost, and flexible printing technique that has become a production approach in many fields of especially analytical chemistry and electrochemistry. 3D printing has recently become widely used in the development of electrochemical biosensors [1]. 3D printing techniques in biosensors mainly focus on the production of desired electrodes with the advantages of low cost, rapid prototyping and production, and minimum waste. 3D printing using fused deposition modeling (FDM) is considered the most common method for the fabrication of integrated electrochemical biosensors [2]. FDM stands out thanks to its features such as rapid prototyping, low cost, modelling, design personalization, sustainable material selection, compatibility between 3D printers mass production and easy integration of 3D-printed multi-components. Thanks to these features, the importance of 3D technologies is increasing in biosensors developed for clinical analysis and point-of-care (POC) applications [3]. FDM 3D printing materials generally consist of polymer and conductive composites. Thermoplastic materials such as polylactic acid (PLA) and acrylonitrile-butadiene-styrene (ABS) in conductive form are commonly used in electrochemical biosensors. The use of conductive filaments based on a mixture of conductive materials and polymers is extremely advantageous for the development of electrochemical biosensors. Materials such as carbon nanotube, carbon black and graphene used as conductive filaments have properties such as high surface area, good thermal and mechanical resistance, and high electrical conductivity [4, 5].

In this study, carbon black/PLA 3D-printed electrodes (3DcbE) were used as the sensor surface and application of biosensor technology was performed by using both hybridization detection of pathogenic microorganism as genosensing and multiple sclerosis (MS) detection as aptasensing technology. Both diagnosis techniques are being carried out for clinical analysis. An ssDNA oligonucleotide representing pathogenic microorganism and MBP-specific aptamer were immobilized on the 3DcbE's. The interactions on the sensor surface were monitored by Differential Pulse Voltammetry (DPV) and Electrochemical Impedance Spectrometry (EIS) techniques. A schematic representation of 3D-printed electrochemical biosensor applications is shown in Figure 1.

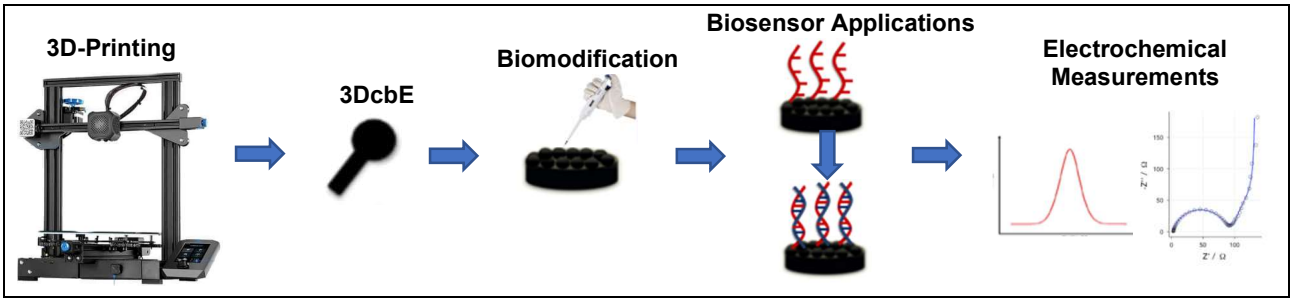

Figure 1. Schematic presentation of 3D-printed electrochemical biosensor applications

Keywords: 3D-Printed Electrode; Electrochemical Biosensor; Clinical Analysis

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Endocrine-Disrupting Compound Detection on Electrospun Nanofibers

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Global climate change is leading to a significant decline in plant production worldwide by causing a wide range of pollution in various environmental matrices and stress-induced degradation of soil quality [1]. For ecological sustainability and survival purposes, it is essential to remove harmful substances from soil, wastewater, and our ecosystem. Physical or chemical approaches (flocculation, photocatalytic degradation, ozonation, coagulation, and Fenton oxidation) for the degradation of organic pollutants are expensive, time-consuming, generally ineffective, and can lead to the production of more resistant compounds [2]. Bioremediation involves a process that includes naturally occurring or introduced microorganisms, namely fungi, archaea, and bacteria, in the degradation of pollutants [3].

Effective bioremediation strategies must be implemented to eliminate the vast amounts of foreign chemical compounds in our environment. Today, the potential of microorganisms in the detection and degradation of environmental pollutants is of great importance. Bhatt and his team have argued that enzymatic bioremediation is the most effective and safest way to convert hazardous and toxic pesticide compounds into non-toxic or less toxic simple molecules [4].

The aim of this proposed study is to synthesize, characterize, and apply nanomaterials for the detection environmental pollutants. To achieve this goal, it is aimed to utilize enzymes to get optical sensors.

Keywords: Nanobiotechnology, nanofibers, biosensor, endocrine-disrupting compound

Acknowledgements
Nur Melis Kılıç thanks to TUBITAK 2211-A National PhD Scholarship Program.

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Integration of Raman Spectroscopy into Microfluidic Platforms for Biomedical Applications

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Microfluidics combined with Raman spectroscopy have become an important tool for various biomedical applications. Raman spectroscopy, easy to use and non-distractive, integrated into microfluidic platforms can give accurate and real-time analysis of biological samples with low sample consumption and high sensitivity [1]. This integration has been used for various biomedical applications, such as disease detection [2], cancer biomarkers detection [3], and identification of biological cells [4]. Moreover, integrating surface-enhanced Raman spectroscopy (SERS) into microfluidics systems amplifies the sample signal and sensitivity of detection. Improving the sensitivity and specificity of the sample makes this system a significant instrument for real-time monitoring, point-of-care diagnostic, and biological studies [4].The noninvasive and label-free nature of Raman spectroscopy, high-resolution molecular imaging capabilities, minimal sample preparation requirements, and compatibility with aqueous solvents make it well-suited for biomedical applications [5]. Additionally, one potential utilization of this technique is to analyze the stage of periodontitis. Our study aims to reveal the stage of periodontitis using oral fluids taken from the patients by utilizing Raman spectroscopy integrated with microfluidics. In conclusion, the combination of Raman spectroscopy with microfluidics may provide great potential for biomedical research and applications. This combination may potentially enable researchers to sensitive detection and real-time analysis of biological fluid samples.

Keywords: Raman spectroscopy; microfluidics; SERS

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The Use of Redox-Active Polymers in Capacitance-Based Aptasensors for Enhanced Food Safety

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Global food safety concerns demand sensitive, convenient analytical methods to detect hazards throughout the supply chain. With safety and quality paramount, there's a rising need for systems to guard against harmful substances. Electrochemical sensors/biosensors offer high sensitivity, selectivity, and rapidity, promising on-site analysis for food safety [1]. Notably, redox capacitance-based biosensors, including electrochemical impedance-derived capacitive spectroscopy, provide label-free detection methods, eliminating the need for solution-phase redox-probes and offering innovative ways to map changes in interfacial redox capacitance as a transducer [2]. In this study, we highlight the potential of utilizing the capacitive signatures of electroactive polymers like polydopamine (PDA) or polyaniline (PANI) as transducer signals in biosensor devices, extending beyond conventional redox self-assembled monolayers. The design of capacitive-based aptasensors involved successive electrochemical deposition of PDA or PANI films and tethering of specific aptamers onto nanomaterials-modified screen-printed carbon electrodes. The modification of capacitive properties of PDA or PANI-modified electrodes in the presence of targeted analytes facilitated label-free detection of kanamycin antibiotic residue linked to antibiotic resistance in pathogenic bacterial strains, and aflatoxin B1, a human group I carcinogen. Notably, these aptasensors demonstrated high specificity towards the target analytes and addressed the food industry challenge by providing precise analytical results within complex food matrices such as milk and corn samples.

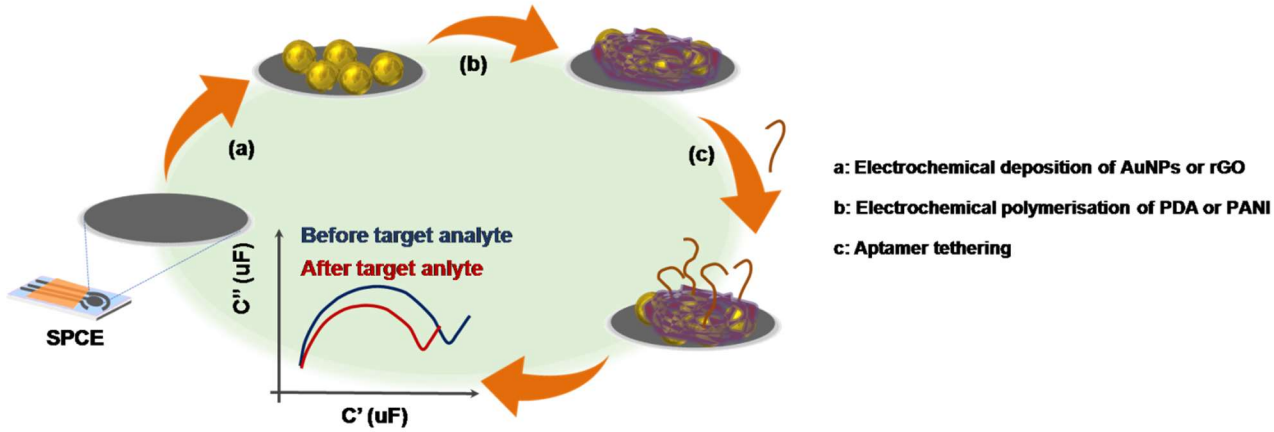

Figure 1. Schematic representation of the stepwise preparation of capacitance-based aptasensors

Keywords: Electrochemical capacitance spectroscopy; Aptasensors; Polydopamine; Polyaniline.

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Development of a Prototype Aptasensor to Determine the Severity of Demyelination

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Myelin basic protein (MBP) makes up to 30% of myelin and it is known to be released into the cerebrospinal fluid (CSF) as a bioindicator of demyelination in multiple sclerosis [1]. In addition, in case of another demyelinating disease or trauma of CNS, MBP is present as a biomarker in human blood serum [2].

Herein, MBP specific aptamer earlier developed for possible therapeutic purposes [3] in mouse model was applied as a bioreceptor for both mouse and human MBP (mMBP and hMBP, respectively) recognition. A biosensor for MBP detection and monitoring was developed by using graphene oxide (GO) integrated onto the working electrodes with aptamer immobilized to create a bioactive layer on the sensor surface for MBP binding. The measurements were carried out using electrochemical impedance spectroscopy (EIS). Using carbon-based nanomaterial with large surface area aggregated with aptamer showed high specificity and affinity to the target molecule and enabled selective and sensitive MBP determination.

The biosensing system designed was optimized and adjusted for application both in CSF and blood serum.
In CSF LOD was 0.65 ng/mL and in the blood serum 0.35 ng/mL correspondingly.

In the future perspective, this developed aptasensor can be implemented for development of prototype product for further clinical use in the MBP determination as PoC analysis.

Keywords: Aptamer; myelin basic protein; biosensor; demyelination.

Acknowledgements
- The Scientific and Technological Research Council of Türkiye (TUBITAK), project number 120Z911
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A Novel Functionalized Nanofiber Based Biosensor for the Detection of *Listeria Monocytogenes*

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Listeria monocytogenes is recognized as a key pathogen in foodborne illnesses and poses a serious threat. Traditional detection methods often require sophisticated laboratory facilities and are time-consuming, making them less feasible. Highly sensitive, rapid, and accurate pathogen detection technologies are needed to ensure food safety. Biosensors can provide rapid and sensitive detection of pathogens. Highly sensitive biosensors can be developed by incorporating nanomaterials such as nanofibers and nanoparticles onto the electrode surfaces to increase surface area. Electrospinning is an effective method for producing nanofibers with a high surface area, making them ideal for use in electrode interfaces. Zeolitic imidazolate frameworks (ZIF) are preferred in biosensor fabrication because of their controllable pore size and large specific surface area. In this study, we developed an impedimetric biosensor based on PLA nanofibers integrating with ZIF-67 nanoparticles and aptamer for the detection of *Listeria monocytogenes*. The surface characteristics of ZIF-67 loaded PLA nanofiber interface on the pencil graphite electrode were analyzed using Fourier transform infrared (FTIR) spectroscopy, scanning electron microscope (SEM), and electrochemical characterization. Experimental results indicated that *Listeria monocytogenes* can be detected sensitively with low detection limits ranging from 10^1 to 10^5 CFU mL^{-1}. The biosensor achieved a limit of detection (LOD) as low as 1.21 CFU mL^{-1} for *Listeria monocytogenes* and exhibited a rapid response time, completing detection within 12.8 minutes. A biosensor with a low detection limit, along with repeatability, reproducibility, sensitivity, and rapid response, has been successfully developed for detecting pathogenic microorganisms. The results indicate that the ZIF-67-loaded PLA nanofiber interface on the pencil graphite electrode is an effective tool for detecting key foodborne pathogens like Listeria monocytogenes.

Keywords: Biosensor, nanofibers, electrospinning, ZIF-67, pathogen, *Listeria monocytogenes*

Acknowledgements
This work was supported by the Scientific and Technological Research Council of Türkiye (TUBITAK) under the Grant Number 123Z573. The authors thank to TUBITAK for their supports.

Electrochemical Biosensing of Interaction between Aptamer and Indium(III) Phthalocyanine Conjugate Targeted Photodynamic Therapy of Breast Cancer

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Electrochemical techniques provide high sensitivity, selectivity, and cost-effectiveness, enabling rapid analyte analysis. Thus, they are widely used for detecting nucleic acids, proteins, and clinical biomarkers. Electrochemical impedance spectroscopy (EIS) examines interfacial properties of biological events at electrode surfaces. AS1411 is a synthetic DNA aptamer known for its strong antiproliferative effects across various cell lines [1]. This aptamer targets nucleolin with high specificity and affinity, which is highly expressed on cancer cell surfaces. Surface nucleolin promotes angiogenesis and tumor growth by binding to growth factors [2]. In this study [3], the interaction between a novel indium(III) phthalocyanine (Pc10) synthesized as a photosensitizer for photodynamic therapy and the aptamer was investigated using an electrochemical impedance spectroscopy technique. Electrochemical measurements were performed on the surface of graphite electrodes. The experimental conditions such as, aptamer concentration, interaction time etc. were optimised. Under optimized conditions, the LOD for Pc10 was calculated and found to be 0.16 µM. The selectivity of this biosensor was examined using cell lines; MCF-7 etc.

Keywords: Indium Phthalocyanine; Aptamer; Electrochemical biosensor; Electrochemical impedance spectroscopy.

Acknowledgements

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Development and Application of Borophene Quantum Dots (BQDs) in Biosensors

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Boron is the 5th element of the periodic table and is one of the 3A group elements with semiconductor and metallic properties, next to carbon and its electronic configuration is similar to the carbon atom. Due to this feature, it has similar properties to carbon nanomaterials. Therefore, it has the properties of nanomaterials such as graphene, which is similar to carbon borophene. Borophene has controlled properties such as electroactive surface area, non-isotopic structure, high electron mobility, thin film storage and can form new compounds with various functional groups. New generation nanomaterials like borophene are increasingly favored for biosensor applications due to their excellent electrochemical performance, high surface-to-volume ratios, enhanced surface-active areas, and high electronic mobility in ultra-thin layers. Currently, researchers are keen on investigating the various dimensional properties of borophene, leading to the study of different dimensional forms of borophene by various research groups. Zero-dimensional borophene (0D) consists of semiconductor nanocrystals ranging from 0-10 nanometers in size, exhibiting optical and electronic confinement due to quantum mechanics, which results in behavior distinct from their bulk form. Borophene quantum dots (BQDs) are 0D nanomaterials with exceptional physicochemical properties such as quantum confinement, chemical stability, high electronic mobility, Fermi band gap, capacitance, conductivity, high quantum yield, and size-dependent luminescence. These properties offer significant potential for drug delivery systems, bioimaging, and diagnostic applications. Biosensors enhanced with borophene quantum dots are notable for their rapid response time and high sensitivity, making them crucial in biomedical applications, environmental monitoring systems, and other precision sensing technologies. BQDs can be synthesized using two main approaches: bottom-up and top-down. Until recently, synthesizing borophene from bulk material through a simple exfoliation process has been difficult. Traditional methods often lead to contamination in BQDs, affecting the intrinsic properties of the samples. However, the advent of liquid phase synthesis of borophene layers via sonochemical exfoliation has marked a significant advancement in this field. In this study, the synthesis of borophene quantum dots, which remain stable in water for 120 days, and the advantages they will have when doped into biosensors are discussed.

Keywords: Borophene, biosensor, borophene quantum dots (BQDs).

Francisella Tularensis Detection via a Novel, Fast and Safe Electrochemical DNA Biosensor Employed with Graphene Quantum Dots as Nanozymes

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Biological warfare agents are infectious microorganisms or toxins capable of causing harm or death to humans. Among these, *Francisella tularensis (F. tularensis)* is recognized as a potential bioterrorism agent due to its high infectivity at minimal doses. Point-of-care biosensors for detecting biological warfare agents are crucial for timely and reliable analysis. This study aims to develop a novel, highly sensitive, non-enzymatic DNA-based electrochemical biosensor for detecting *F. tularensis* utilizing Graphene Quantum Dots (GQDs) with a cost-effective screen-printed gold electrode. The sensor is constructed by immobilizing a biotinylated DNA capture probe (ssDNA) onto the screen-printed gold electrode surface, which then hybridizes with single-stranded target oligonucleotides (ssGDNA). The sensor fabrication process is validated through UV-Visible spectroscopy, Atomic Force Microscopy (AFM), and electrochemical techniques. The biosensor demonstrates a detection limit (LOD) of 0.1 nM, with a correlation coefficient (R^2) of 0.993, achieved within twenty-five minutes without the need for pre-enrichment. This study presents a highly sensitive and cost-effective GQDs-based SPGE/ F. tularensis DNA assay, suitable for integration into portable electrochemical devices that combine sample processing and detection in a single cartridge, eliminating the need for PCR prior to detection.

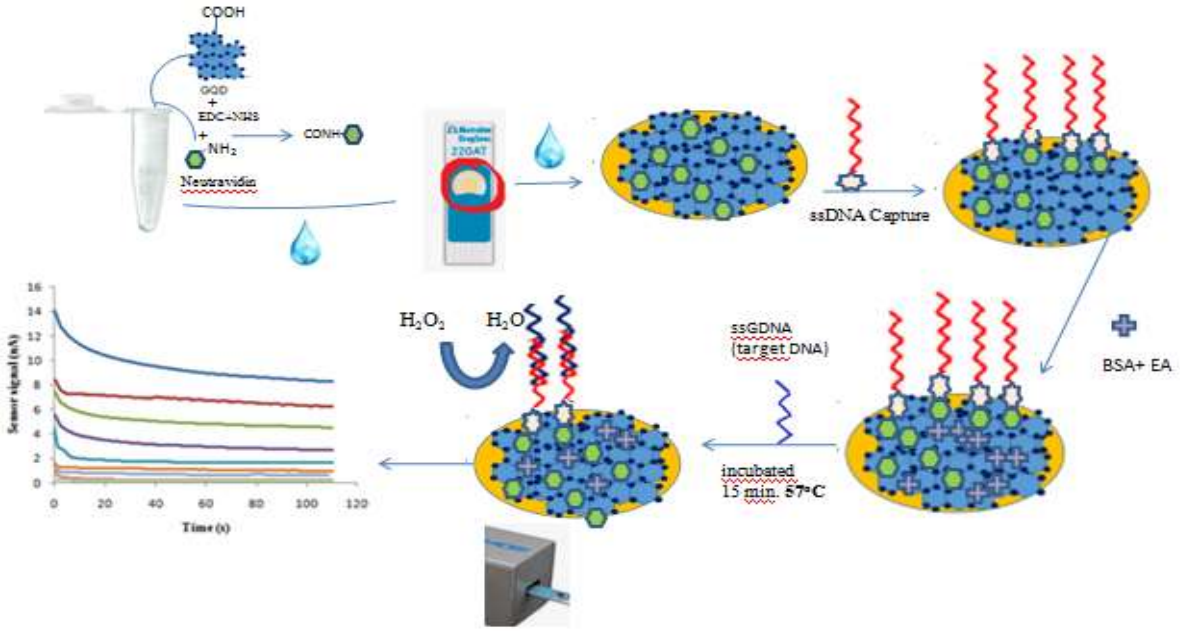

Figure 1. Principle of the GQDs based DNAsensor for F. tularensis detection.

Keywords: Electrochemical DNA sensor, Francisella tularensis, Graphene Quantum dots, bioterrorism.

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Design of Functional Fullerenol-Based Electrochemical Nanobiosensors

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In recent years, fullerenes, an important class of nanomaterials, have been thoroughly studied. Fullerenes have significant potential power for molecular engineering, new molecular materials, and supramolecular chemistry due to their unique electronic and chemical properties [1]. Fullerenols are fullerenes' hydroxy derivatives, and depending on their degree of hydroxylation, they are well-soluble in water [2]. In addition to being water-soluble, amino acid-functionalized fullerenols are utilized as enzyme mimics in aqueous solutions. It is additionally conceivable to tie various particles (little natural atoms, chemicals, and so on) covalently. Taking into account this large number of properties, amino corrosive functionalized fullerenols can possibly be assessed as nanomaterials that are not difficult to blend and worth concentrating on in both natural hardware and sensor applications. Electrochemical methods of following the relevant analytes provide systems that are low-cost, reliable, selective, highly sensitive, quick, and suitable for on-site analysis.

Herein, novel amino acid functional fullerenols were synthesized, characterized, and their potential use in sensor applications were evaluated. The performance of the sensor was validated, including recovery studies on real sample applications, to assess method accuracy. The sensor exhibited a lower limit of detection (LOD), and a wide linear range for target analyte detection. Morphological and electrochemical characterizations of the sensors were conducted using FE-SEM, CV, and EIS techniques. Additionally, the biosensor was utilized to investigate the pyridostigmine (PDT) inhibition of AChE activity, with an IC50 value of 1.01 mM PDT. The inhibitory impact of PDT on the biosensor was investigated in engineered human serum, manufactured human pee, and drug details containing PDT's dynamic fixing under ideal biosensor conditions.

Keywords: Fullerenol, amino acid functional fullerenol, electrochemical (bio)sensor, pyridostigmine

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A Novel Acetylcholinesterase Biosensor for the Determination of Pesticides

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The amount of land utilized for agriculture is declining day by day for a variety of reasons, including accelerated population increase, erosion, unchecked industrial zone expansion, and the construction of new highways. For this reason, various techniques are being developed to maximize yields in current agricultural regions while minimizing costs. The use of pesticides is the most significant of these techniques [1]. Although; pesticides are used to eliminate destructive pests, they could harm humans, other living things, and the environment [2]. Analysis of pesticide residues is important because they have high toxicity and bioaccumulation effects. Pesticide analyses are generally performed using advanced analytical methods such as high-performance liquid chromatography (HPLC) or gas chromatography (GC).

On the other hand, developing enzyme biosensors for determining trace amounts of pesticides is crucial due to high sensitivity, selectivity, low cost, and short analysis time compared to alternative methods. Organophosphates and carbamates are two important classes of pesticides with broad biological activity that can inhibit the enzyme acetylcholinesterase (AChE), which is responsible for the catalysis of acetylthiocholine (ATCh) [3]. Biosensors based on the acetylcholinesterase enzyme inhibition mechanism could be used to determine these pesticides due to their high sensitivity and selectivity. Determining the amount of thiocholine formed in the medium as a result of the reaction of acetylthiocholine (ATCh) with the acetylcholinesterase enzyme on the electrode surface (Figure 1) could be used to determine pesticides. In this study, a new acetylcholinesterase biosensor was designed for the determination of pesticides. Measurements were carried out using the square wave voltammetry (SWV) technique. In this context, the optimum analysis time, frequency, and amplitude of the designed biosensor were determined by square wave voltammetry as 30 min, 25 Hz, and 25 mV, respectively. Validation studies of the biosensor are ongoing.

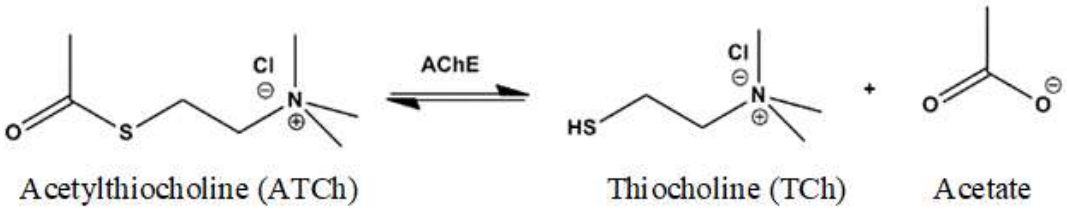

Figure 1. Reaction catalyzed by acetylcholinesterase (AChE)

Keywords: Thiocholine; voltammetry; biosensor

Acknowledgements
We are grateful to Gazi University Scientific Research Projects Coordination Unit (Project number: FDK-2022-7739) for providing financial support.

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Electrochemical Immunosensor Based on Molybdenum Compounds for Diagnosis of Acute Myocardial Infarction

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One of the main causes of death worldwide is cardiovascular diseases (CVD), such as acute heart failure or myocardial infarction [1]. The main purpose of research is the creation of quick, affordable screening electrode. For early diagnosis of acute myocardial infarction (AMI) was chosen a specific biomarker - Cardiac troponin I (cTnI) [2].

The electrochemical detection of cTnI was improved in this work by adding a highly reactive – a cross linking agent, dialdehyde reagent [3] and due to its physical and chemical characteristics molybdenum compounds [4] to a glassy carbon electrode, then by immobilizing a recognition element anti-cTnI antibodies [5].

To evaluate the performance of the biosensor, differential pulse voltammetry (DPV), electrochemical impedance spectroscopy (EIS), cyclic voltammetry (CV), were used. Additionally, surface morphology change of the electrode was examined using EDX and scanning electron microscopy (SEM). It was shown that the created biosensor could identify low concentrations of cTnI. The biosensing performance was investigated for cTnI detection in human blood serum. Future research will concentrate on optimizing the matrix effect and preparing patient blood serum samples to reduce contaminants that impede analysis.

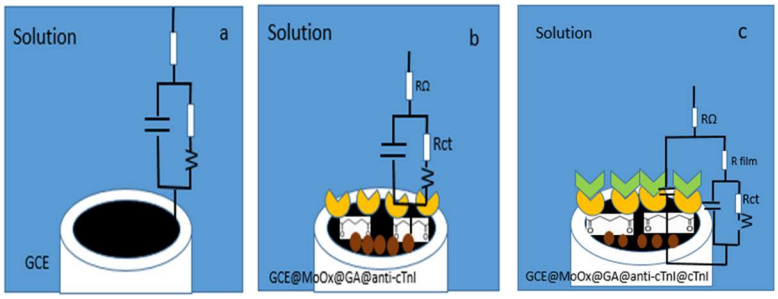

Figure 1. Electrochemical scheme of GCE/MoOx/GA/anti-cTnI electrode

Keywords: immunosensor; molybdenum oxide; cardiac troponin I (cTnI); acute myocardial infarction

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6th International Congress on Biosensors

POSTER PRESENTATIONS

A Label-Free Electrochemical DNA Biosensor for the Rapid and Sensitive Detection of Ebola Virus

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Ebola viruses, are single-stranded RNA viruses. first identified in 1976 and responsible for major outbreaks in 2014. The outbreak primarily in West Africa from 2013 to 2016, affected over 25,000 people and resulted in over 10,000 deaths [1]. Ebola virus is a potential bioterrorism agent that is highly infectious at even very low doses. The high prevalence of diseases is often due to the lack of suitable detection tools. Biosensors for biological warfare agents are simple yet reliable point-of-care analytical tools.

The aim of this study is to produce a new, highly sensitive, non-enzymatic DNA-based electrochemical biosensor using graphene quantum dots (GQDs) with a cost-effective screen-printed gold electrode (SPGE) for the detection of the Ebola virus. A biotinylated RNA complementary capture probe (ssDNA) will be immobilized on the surface of the screen-printed gold electrode and hybridized with single-stranded target oligonucleotides (ssDNA) for the production of the Ebola virus DNA sensor (Figure 1).

A screen-printed gold electrode utilizing GQDs as nanozymes serves as a rapid, specific, label-free, and cost-effective biosensing system [2]. It can be integrated with all electrochemical measurement devices and made portable for field use.

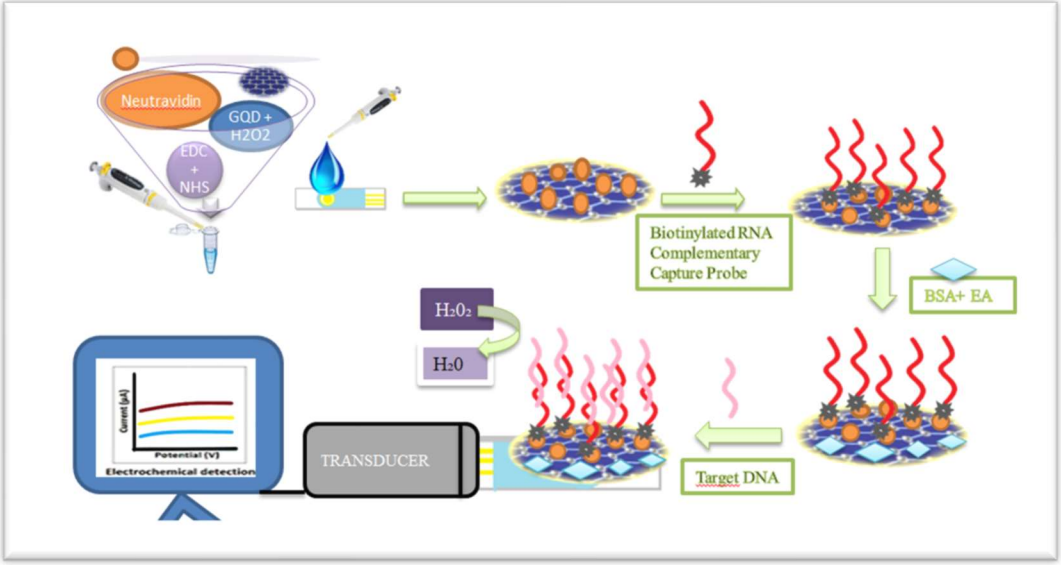

Figure 1. Schematic illustration of electrochemical DNA biosensor for detection of Ebola virus

Keywords: DNA Biosensor; Ebola virus; GQD; Fast Detection

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Detecting Point Mutations in Genomic Human DNA Using Electrodes Modified with DNA-Tethered Nanomaterials and TMB/MB as Redox Signal Reporters

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Single nucleotide polymorphisms (SNPs) are abundant in human genomic DNA and directly linked to higher susceptibility to ovarian and breast cancer [1,2]. Therefore, suitable methods for their selective and sensitive sensing are of general interest for researchers and medical personal. We designed two different strategies to detect SNPs present in inteleukin-6 (IL6) and transforming growth factor β1 (TGFβ1) genes using a DNA-modified magnetic particles or gold nanoparticles, SPCEs as electrochemical transducing interfaces, and tetramethylbenzidine (TMB) or methylene blue (MB) as redox intercalators [3,4]. First, several electrodes were prepared to detect T > G and T > G within the IL6 and TGFβ1 synthetic DNA sequences, showing that both methods have wide ranges of linearity (over 6 decades fM to nM concentrations) and low limits of detection. The main influential parameters were optimized to ensure the highest sensitivity of the methods using the redox signal intensity and signal-to-blank (S/B) ratio as selection criteria. More importantly, the bioelectrodes were used to detect the SNPs in scarcely diluted human DNA (digested by EcoR I), collected from 70+ patient and control donors, previously analyzed by PCR. Our results showed that the bioassays can reliably distinguish between heterozygous (TG or TC genotype) and homozygous (GG or CC genotype) in respect to the control subjects (TT genotype), where the differences are statistically highly significant (p-value < 0.001). Thus, the bioassays are useful to conduct cohort studies targeting one or more SNP in human DNA.

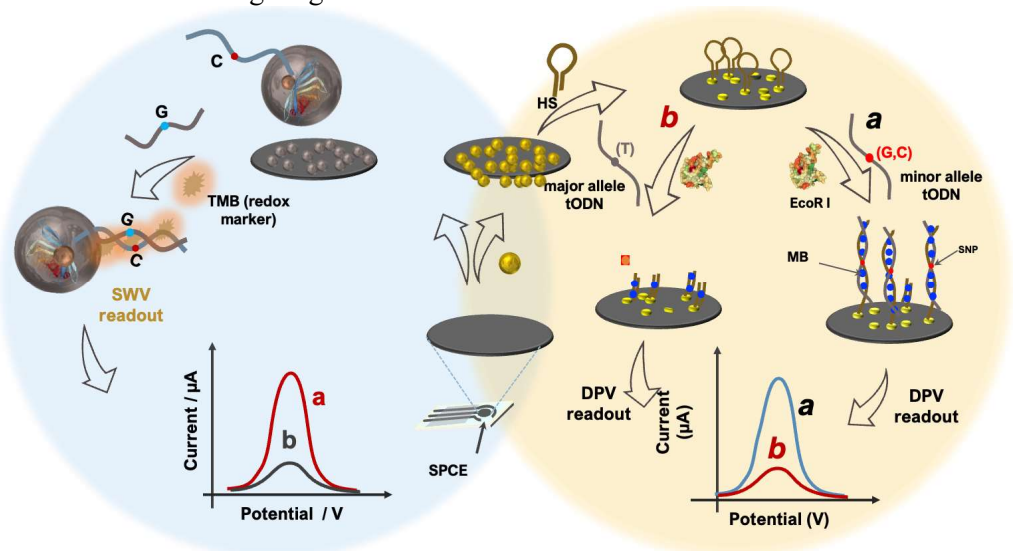

Figure 1. Schematic representation of the two designed methods for SNP sensing in genomic human DNA

Keywords: Point mutations; Cancer; Modified electrodes; Electrochemistry; DNA; Real samples.

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Development of a Novel Electrochemical In Vitro Assay for Real-Time Neurotoxicity Assessment

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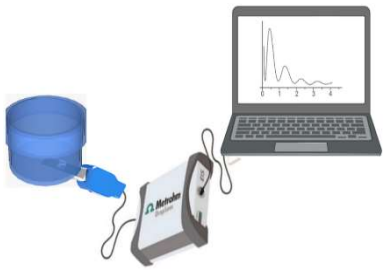
The intricate nature of the nervous system and the ethical concerns surrounding animal testing call for alternative methods to assess neurotoxicity. In vitro approaches, which analyze cellular responses in a controlled setting, present a promising solution. However, current in vitro techniques have not yet matched the practicality and accuracy of in vivo assessments [1]. This highlights the necessity for innovative strategies capable of delivering dependable, real-time, and economical data on neurotoxic effects. This study aims to develop an innovative yet simple in vitro neurotoxicity test using electrochemical methods. Developing an electrochemical in vitro neurotoxicity assay offers numerous benefits, ranging from real-time monitoring to contributions to personalized medicine and scientific research. This new system will facilitate real-time measurement, allowing for rapid, cost-effective, and quantitative toxicity assessments of various drugs. Additionally, it will provide both quantitative and semi-quantitative evaluation capabilities through time-dependent analysis. Briefly, a CNC-cut petri dish was glued to a screen-printed carbon electrode to restrict the growth of neuroblastoma cells (SH-SY5Y cells) to the working electrode (WE) surface. The WE was modified with poly-l-lysine to enhance both the electrochemical signal and cell adhesion. Cell viability was measured in 1 mM $[Fe(CN)_6]^{3-/4-}$ using differential pulse voltammetry, and the results were normalized against those of the MTT test (3-(4,5-dimethyl thiazol-2-yl)-2,5-diphenyl tetrazolium bromide). The findings were also confirmed by the Calcein-AM/PI cell viability kit. H_2O_2 and doxorubicin will be used to demonstrate the system's potential in neurotoxicity assessment. This assay is expected to significantly contribute to scientific knowledge and personalized medicine.



Graphic abstract: Schematic representation of an electrochemical neurotoxicity system

Keywords: Electrochemistry; Toxicity; Nerve Cell; Drug

Acknowledgements
This research was supported by the TUBITAK (Scientific and Technological Research Council of Türkiye) [No:1929B012300472].

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Miniature Impedimetric Hemoglobin Immunosensor for Detection of Gastrointestinal Bleeding

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Gastrointestinal bleeding is a critical medical condition requiring prompt detection and diagnosis. Although there are several diagnosis methods exists [1,2], there is a still need for fast, low-cost and accurate point-of-care devices. In this study, an impedimetric hemoglobin immunosensor aimed at early detection of gastrointestinal bleeding. Our approach involves the use of a novel and miniature electrochemical impedance spectroscopy (EIS) instrument for accurate measurement of hemoglobin level, so that it can be used as an ingestible sensor in the future [3]. Initially, the performance of the immunosensor was validated by comparing its measurements with those obtained from a commercial benchtop EIS instrument using a redox solution. Subsequent tests in simulated gastrointestinal (GI) fluid demonstrated the sensor's capability to detect hemoglobin concentrations as low as 10 mg/mL. These findings highlight the potential of our hemoglobin immunosensor as a reliable and effective diagnostic tool for gastrointestinal bleeding, with significant implications for improving patient outcomes through early intervention.

Keywords: Ingestible sensors; electrochemical impedance spectroscopy; hemoglobin immunosensor; gastrointestinal bleeding.

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Metal-Organic Framework-Derived Hierarchical Flower-Like DyCo-Layered Double Hydroxide Integrated Nitrogen-Doped Graphene for Diphenylamine Detection

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Diphenylamine (DPA) is an environmental pollutant that can be potentially toxic. As a result, it is crucial to use basic and affordable analytical techniques to detect DPA. Electrochemical detection of DPA is a cost-effective and simple method. Modifying the electrodes with nanomaterials can enhance the electrochemical characteristics and sensitivity of the sensor. The layered double hydroxides (LDHs) exhibit relatively high redox activities, making them a preferred choice for electrochemical energy storage and sensor applications.[1] Nevertheless, LDHs synthesized through hydrothermal methods suffer from restacking and limited specific surface area, thereby reducing active sites.[2] Therefore, template methods using MOFs are preferred that enhance the electrochemical performance. Herein, metal-organic framework (MOF) derived dysprosium cobalt-layered double hydroxide integrated nitrogen-doped graphene (DyCo-LDH/NG) is reported to fabricate the DPA sensing platform. The electrochemical oxidation of DPA is enhanced by the exceptional electrocatalytic activity and electron transfer properties of the DyCo-LDH/NG nanocomposite. Interestingly, the glassy carbon electrode (GCE) modified with DyCo-LDH/NG nanocomposite demonstrates a large linear detection range (0.05-470 µM) and a low limit of detection (0.012 µM). The density functional theory (DFT) study examines DPA's energy levels and electron transfer sites during the electro-oxidation process. Furthermore, the practical efficiency test of the developed DPA sensor demonstrates a substantial recovery in fruit samples.

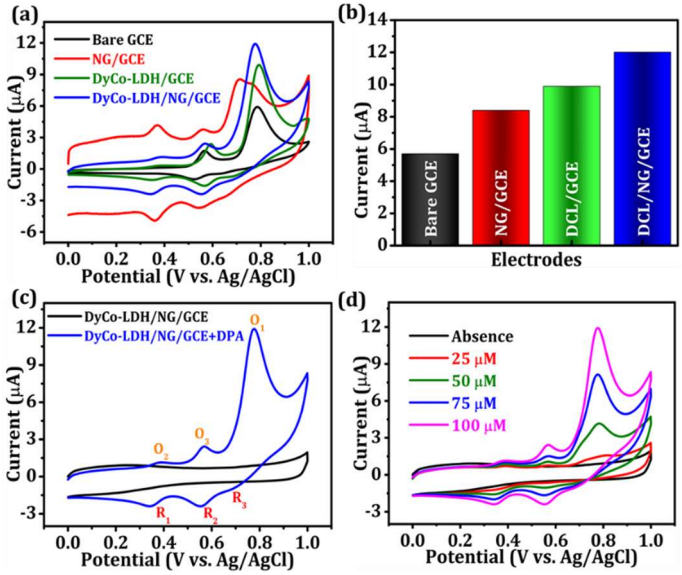

Figure 1. (a) CV curves and (b) bar diagram of bare GCE, NG/GCE, DyCo-LDH/GCE, and DyCo-LDH/NG/GCE; (c) CV curves of DyCo-LDH/NG electrode in the absence and presence of 100 µM DPA; (d) CV curves of DyCo-LDH/NG/GCE for various concentrations of DPA (25 to 100 µM) in 0.1 M PBS with pH 3 at the scan rate of 50 mV/s.

Keywords: Diphenylamine; Fruit samples; Layered double hydroxide; Density Functional Theory;

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Colorimetric Detection of CD36 on Electrospun Nanofibers

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In recent years, Electrospun nanofibers (ESNFs) have demonstrated great potential to develop bio-based detection technologies owing to their large surface area, controllable surface conformation, suitable surface modification, and high-level biocompatibility [1]. ESNFs can be produced simply, effectively, and with desirable properties via an electrospinning technique [2]. Electrospinning parameters such as polymer concentration, viscosity, solvent system, temperature, humidity, flow rate, and applied voltage are crucial for producing uniform ESNFs that are free from beads. [3]. Biosensors based on ESNFs have several fields of applications.

In this study, an ESNFs-based sensor platform was designed to detect CD36 protein, called a biomarker of atherosclerosis, which is considered one of the cardiovascular diseases. Firstly, nanofibers were produced by electrospinning to develop a paper-based sensor platform. Secondly, gold nanoparticles (AuNPs) were synthesized by the Turkevic method. Then, aptamer against CD36 was conjugated onto AuNPs for colorimetric detection. Finally, the colored spots of CD36 were followed optically on the ESNFs. The linear range of the developed ESNFs-based sensor was determined as 25-500 ng/mL, and the limit of detection (LOD) was calculated as 27.78 ng/mL for CD36 by smartphone using RGB color analysis.

Keywords: Nanomaterial; Nanofiber; Paper-based sensor

Acknowledgements
This work was supported by Ege University Scientific Research Projects Coordination Unit. Project Number: 31999

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Polymer-clay Nanocomposite as an Immobilization Matrix to Prepare Enzyme Biosensors

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In catalytic biosensors, the immobilization of biomolecules in a suitable matrix is one of the vital parameters for obtaining improved systems. Clays, which are intercalated with various organic compounds, have a great tendency to develop biosensors with high stability, sensitivity, and reproducibility [1].

Nanocomposites have some advantages for use in bio-related areas because of their flexibility, biocompatibility, and higher mechanical stability. Furthermore, the surface area of clay particles increases due to exfoliation of the clay layers in the polymer matrix, and it provides more interaction points between the matrix and biological materials during immobilization. These characteristics are key points in preparing biosensor systems without decreased activity of the biomolecules after immobilization [1]. The success of immobilization directly affects the biosensor performance parameters such as operational or storage stability, detection limit, linear range for the analyte, selectivity, sensitivity, repeatability, and reproducibility.

Herein, a polymer-clay nanocomposite based on natural silicate montmorillonite (Mt) and a biodegradable polymer was prepared and characterized by fourier transform infrared spectroscopy (FT-IR), thermogravimetric analysis (TGA), differential thermogravimetric analysis (DTG), and X-ray diffraction (XRD). Then, the resulting matrix was used as a fixation matrix for alcohol oxidase (AlOx), which was selected as a model enzyme. The clay-polymer nanocomposite was deposited on the glassy carbon (GC) electrode surface by electropolymerization method. For the electrochemical characterization of this composite material, cyclic voltammetry (CV), differential pulse voltammetry (DPV), and electrochemical impedance spectroscopy (EIS) measurements were taken using biosensor systems. The prepared surface was modified with AlOx and a biosensor system was prepared for alcohol determination.

After the optimum pH value for this prepared enzyme biosensor was determined, a linear range was obtained for alcohol. As a result, this study aims to develop a new sensor system for alcohol determination and thus be a pioneer in the creation of stable sensor platforms using clay-polymer nanocomposites.

Keywords: Montmorillonite; clay-polymer nanocomposites; alcohol oxidase; biosensor

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Development of Different Screen Printed Electrodes Based Sepsis Biosensors and Determining the Most Effective Biosensor System

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Sepsis is a life-threatening state of infection. The infection that causes sepsis may be fungal, parasitic, or viral, but it may also be caused by trauma, burns, or postoperative infection. A late diagnosis of sepsis in a patient causes a high rate of death. Today, a series of blood tests and imaging techniques are performed to diagnose sepsis and are interpreted individually by experts. Therefore, the diagnosis of sepsis sometimes takes days to get darker, and with each hour that is delayed, the patient gets closer to going into septic shock [1,2]. Electrochemical biosensors are a good solution to this problem because they respond in a short time, can be miniaturized, and do not require experts to interpret the results. In this work, we developed different electrochemical immunosensors for the rapid diagnosis of sepsis. For this purpose, carbon (C), gold (Au), multi-walled carbon nanotubes (MWCNT), single-walled carbon nanotubes (SWCNT), graphene and graphene oxide (GO) based screen printed electrodes (SPEs) were used as transducer. While C, Au, SWCNT and MWCNT were purchased commercially, graphene and GO nanostructures were synthesized and characterized by our group. Scanning electron microscopy (SEM), EDS (Energy dispersive spectroscopy), X-Ray diffraction analysis (XRD) and Fourier transform infrared (FT-IR) spectroscopy were used for the structural characterization of nanostructures. Procalcitonin (PCT) was selected as a biomarker for sepsis diagnosis. By using different types of SPEs, six sepsis biosensors were prepared, and the responses of these biosensors were compared to each other. The electrochemical characterization of the developed biosensors was performed with electrochemical impedance spectroscopy technique. After determining the most effective sepsis biosensor system, optimization, analytical characteristics and storage stability studies are planned to be carried out in the continuation of the study.

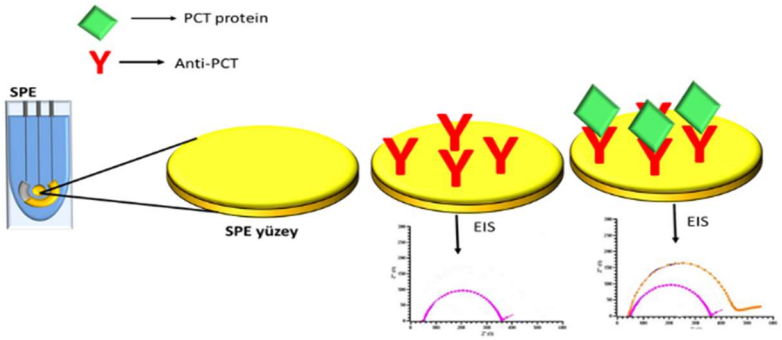

Figure 1. Scheme showing the preparation of the electrochemical sepsis biosensor**.**

Keywords: Sepsis; Electrochemical biosensors; Rapid test; PCT biomarker.

Acknowledgements
This study is supported by Tubitak BIGG 1512 program with 2230115 the project number.

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Development of Electrochemical and Colorimetric *Escherichia Coli* Detection Systems Based on Benzoquinone

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With the advancement of global trade and human society, concerns about pathogenic biosecurity have intensified, particularly regarding pathogens like *Escherichia coli* (*E. coli*), a key indicator of water pollution. To address the urgent need for fast, user-friendly, cost-effective, and accurate detection of *E. coli*, we developed a dual-signal biosensor that combines colorimetric and electrochemical methods. During E. coli cell respiration, glucose undergoes a reaction with an intact redox enzyme. This enzyme becomes reduced, and subsequently, electrons are provided to the electron acceptor (BQ), either directly or via a suitable site in the respiratory chain. When *E. coli* cells are appropriately aligned with electrodes, their enzymatic actions reduce BQ to hydroquinone (HQ), which then interacts with the remaining BQ to form quinhydrone, a red-colored complex. At specific BQ concentrations, a change in color may indicate the concentration of *E. coli*. This compound represents a potential avenue for developing novel antimicrobial agents against *E. coli* and other bacterial pathogens. The colorimetric detection, exploiting the reaction between *E. coli* and BQ, yields results within 5 minutes and is interpretable in real-time using RGB analysis, eliminating the need for large-scale instrumentation. The electrochemical detection, enhanced by incorporating antibodies, detects bacterial concentrations as low as $1.0x10^1$ CFU/mL using Differential Pulse Voltammetry (DPV), Cyclic Voltammetry (CV), and Impedance Spectroscopy (EIS), with a total detection time of approximately one hour. Validation with sterile PBS, bacteria-free sterile MHB medium, autoclaved *E. coli*, and live *Staphylococcus aureus* (ATCC 25923) confirmed the biosensor's high sensitivity and specificity. This dual-signal approach addresses the limitations of each individual method, offering a robust and versatile solution for the rapid and specific detection of E. coli, thus enhancing public health monitoring and ensuring water safety.

Keywords: E.coli; biosensor; colorimetric; electrochemical detection

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This study was supported by the 2210/D National Industrial MSc/MA Scholarship Program

Development of Lateral Flow Immunosensor for Detection of Growth Hormone

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The use of biosensors in different areas has diversified in recent years with the development of technology. It is obvious that biosensors developed to access data quickly and easily provide convenience in our daily life. Lateral flow immunosensors (LFA), which we encounter within biosensor technology, are used in many areas such as medicine, environment, food, biomedical and pharmacy. The reasons for using these systems are that they are easily accessible, do not require an expert, and are low in cost [1,2]. Lateral flow tests provide results in a short time and make great contributions to the initial diagnosis phase, called home care services, without resorting to a healthcare institution. Hormones, proteins, nucleic acids and many other biomarkers can be determined with LFA. In this study, a lateral flow immunosensor was developed for the determination of growth hormone, which plays an important role in metabolic activities in human growth and development. Monitoring the blood level of growth hormone, a peptide consisting of 191 amino acids, is very important in childhood and adulthood [3,4]. Too much or too little secretion of growth hormone in the human body causes diseases such as dwarfism, gigantism and acromegaly. Therefore, an LFA test kit was obtained to determine and monitor the amount of growth hormone in the blood. In the study, optimizations were made on the membrane, sample pad and conjugation pad, which are the basic components of the LFA system. Qualitative and quantitative determination of growth hormone was made with the obtained sensor. The LOD value of the designed sensor for growth hormone was calculated as 8.38 ng/mL and the LOQ value was 25.40 ng/mL. In addition, the sensitivity value of the developed sensor was found to be 5.37 mV/ng mL^{-1}. In short (2 hours, 24 hours) and long term (6 months) stability studies of the developed LFA system, it was observed that the test response remained stable even after 6 months. The developed LFA test kit was tested for verification using the ELISA method, which is considered the standard method in this field. While the recovery values obtained by the ELISA method performed on commercial artificial serum samples were found to be between 77.19% and 100.20%, this value was found to be between 79.00% and 109.34% in the LFA verification tests. These results showed that the developed LFA system can be used for quantitative as well as qualitative determination of growth hormone.

Keywords: Acromegaly, Biomarker, Growth hormone, Paper-based sensors, Lateral flow tests

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Electrochemical Detection of Foodborne and Human Pathogen *Staphylococcus aureus* using Graphene Quantum Dots

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Foodborne illnesses are pretty common with approximately 48 million people contract foodborne illness every year. (CDC, 2024) [1]. One of the top 5 food-borne microorganisms that cause diseases is the *Staphylococcus aureus* (*S. aureus*) bacteria. *S.aureus* is not only a foodborne pathogen but also a human pathogen, acting as an opportunistic pathogen with the potential to cause disease. Due to fatalities caused by antibiotic resistant strains in recent years, *S. aureus* has been recognized as one of the deadliest pathogens [2]. *Staphylococcus aureus* presents a significant threat as it can be found in contaminated food and naturally within the human body. Rapid and sensitive detection of this deadly pathogen is essential for ensuring food safety and safeguarding public health. Currently, the diagnosis of *S. aureus* is performed using time-consuming conventional methods. Electrochemical biosensors, are advantageous as they are quick and allow for field applications. This study aim of the development a biosensor which is label-free, antibody-based immunosensor using graphene quantum dots (GQDs) nanomaterial for the rapid detection of *S. aureus* with high specificity and sensitivity. The methodology of the immunosensor to be developed is as follows; the screen-printed gold electrode (SPGE) surface was immobilized with antibody. The areas where antibodies could not bind were blocked with bovine serum albumin (BSA) and ethanolamine (EA). Outcomes of this study a highly sensitive, cost effective, GQDs based SPGE/ *S.aureus* immunoassay is to reveal. This process is also suitable for miniature electrochemical devices that incorporates sample detection into a single chip suitable for point of-care without requiring any pre-treatment before detection.

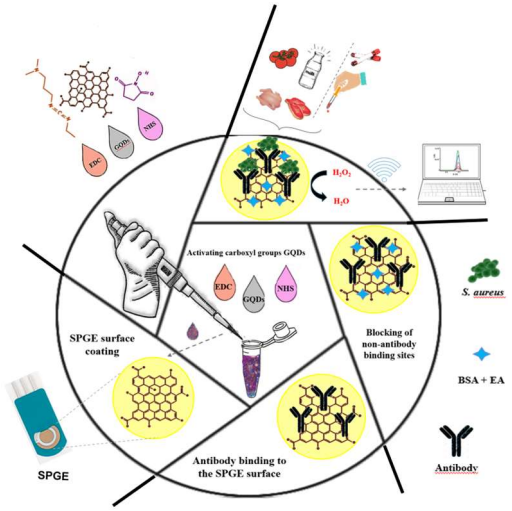

Figure 1. The principle of the immunoassay to be developed for the electrochemical detection of *S.aureus.*

Keywords: Fast detection; Electrochemical biosensor; *Staphylococcus aureus*; Graphene Quantum Dots

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Polymer-Based Encapsulation of Flavonoids via Electrospinning for Nutraceutical Applications

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Mixing the active ingredients with the polymer solution and electrospinning is a common method for encapsulating the active ingredients into fibers. Food processing greatly depends on the encapsulation of bioactive substances for eventual inclusion into food. The technique of encapsulation involves coating or encapsulating active ingredients, such as food bioactive compounds or living cells, inside micro-or nanoscale-sized particles or capsules made of polymers based on lipids, proteins, and carbohydrates. Bioactive chemicals that are encapsulated are protected from environmental stressors and have their stability, bioavailability, and physicochemical functions improved. Since electrospinning is a workable way to generate dry, food-grade, nano-scaled materials with excellent encapsulation efficiencies, it is a viable technique for encapsulating food bioactive. [1-3]

There are studies showing that flavonoids have excellent multiple bioactivities such as antiviral, antioxidant, antibacterial, anti-inflammatory, and anti-tumor. In this study, it was aimed to encapsulate flavonoid mixtures using electrospinning technique and use them as a controlled release system in the nutraceutical supplement industry. [1-3]

Two different polymers (polycaprolactone (PCL) and poly lactic acid (PLA)) and three different flavonoids (rutin, naringin, hesperidin) were selected in this study. PLA (2.5%) and gelatin (7.5%) were dissolved in 20 mL hexafluoro-2-propanol (HFIP), and the active ingredients were added to the solution at the rate of 10% of PLA. While preparing the electrospinning solution containing PCL, 80000 kDa PCL (10%) was dissolved in a mixture of Methanol: Chloroform = 40:60 and active ingredients were added. FTIR analyzes of the fibers were performed. Quantification and bioactivity analyze are planned to be completed. [4-5]

Keywords: electrospinning, rutin, naringin, hesperidin, polymers

Acknowledgements
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Monitoring of Palladium in Living Cells and Environmental Samples with a New Sensitive Fluorescence Sensor

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Palladium (Pd) is a significant heavy metal with outstanding catalytic properties, extensively utilized in the pharmaceutical industry and organic chemistry [1]. Due to the detrimental impact of palladium on human health and the environment, there is a pressing need for efficient and convenient analytical techniques [2]. In this context, we have created a simple fluorescent switch-on probe, INX-Pd, for the selective determination of Pd^0. The allyl carbonate in INX-Pd could be entirely cleaved by Pd^0 to produce the intermediate INX-OH, resulting in distinct colorimetric and fluorometric alterations. INX-Pd displayed high sensitivity in detecting Pd^0, with a detection limit of 56.0 nM, and a fast response time (~2.0 min). INX-Pd was successively utilized to determine Pd^0 in drugs, water, soil and various foodstuff samples as well as smartphone and test strips. Moreover, cell imaging experiments demonstrated that INX-Pd is suitable for imaging Pd^0 in living cells.

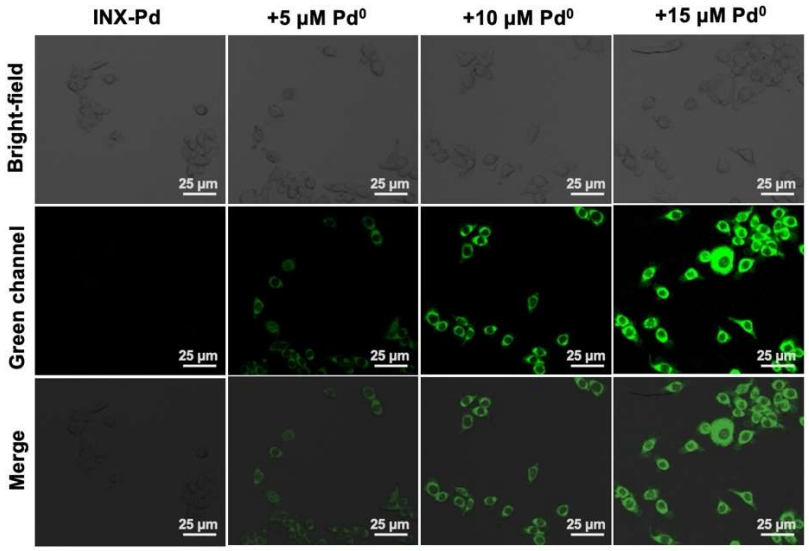

Figure 1. Bright-field, fluorescence, and overlay imaging in HeLa cells utilizing INX-Pd and varying concentrations (5.0, 10.0, and 15.0 μM) of Pd^0.

Keywords: Bioimaging; Fluorescent; Palladium; Deallylation

Acknowledgements
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Comparative Performance of ZnO Nanoparticle-Modified Working Electrodes: Exploring the Impact of Electrode Selection

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Working electrodes play a crucial role in high-performance electrochemical biosensors, facilitating electron transfer reactions, enhancing modification and stability of surfaces, and other key functions. The surface of the working electrode directly influences bio-recognition events and subsequent electron transfer, impacting the sensitivity and selectivity of the biosensor. ZnO nanoparticles offer various properties to enhance the performance of working electrodes in biosensing applications. Due to their stability, band gap engineering possibilities, and cost-effectiveness, ZnO nanoparticles have attracted significant interest in recent years [1].

This study presented a comparative analysis of ZnO nanoparticle-modified working electrodes. By examining these factors, it was aimed to provide valuable insights for selecting the optimal combination of working electrode and ZnO nanoparticle modification for developing high-performance biosensors [2, 3]. This study was based on the investigation of the impacts and effects of various working electrodes and the synthesis methods on electrochemical behavior of ZnO-based biosensors. To achieve this, three types of working electrodes—glassy carbon electrode, screen-printed electrode, and 3D-printed electrode—were modified with green-synthesized ZnO nanoparticles synthesized from *Haplophyllum armenum* leaf extract. The synthesis was performed using a one-step microwave-assisted method, and the synthesized particles were purified by centrifugation. Subsequently, all electrodes were modified with the synthesized ZnO nanoparticles, considering the surface area. Moreover, reduced graphene oxide was also used to modify the electrodes' surfaces with ZnO nanoparticles to examine the synergistic effect and the modifying abilities of the working electrodes.

Electrochemical results were obtained toward a redox probe and dopamine as a model analyte. The results investigated the response of the electrodes in terms of sensitivity, initial cost, ease of fabrication, and reusability. Therefore, the study offers valuable insights for selecting the most suitable electrode type, considering both technical and economic factors. While the fabrication cost of 3D-printed electrodes were calculated as ~$0.03, commercial screen-printed and glassy carbon electrodes cost $4.65 and $190.00, respectively.

Keywords: 3D printed electrode, glassy carbon electrode, screen printed electrode, ZnO nanoparticles

Acknowledgements
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Development of Graphene Oxide-Based Label Free Electrochemical Genosensor for the Detection of *E. coli*

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Pathogenic microorganisms are infectious agents that cause disease. Despite victories against infectious diseases with the development of vaccines and antibiotics, new and multidrug-resistant pathogens continually emerge. Pathogens include microorganisms such as bacteria, fungi, protozoa, and viruses. Foodborne, waterborne, and airborne pathogens enter the body through various infection routes and are responsible for more than 15 million deaths yearly [1,2]. *Escherichia coli (E. coli)* is one of the most common pathogenic bacteria in nature. Symptoms of illness caused by pathogenic *E. coli* infection can range from fever, malaise, diarrhea, severe dehydration, and death. Therefore, detecting *E. coli* is critical in environmental, medical, pharmaceutical, and food safety issues [3]. Electrochemical biosensors are frequently used in clinical diagnostic, environmental, and food monitoring applications, providing rapid response, robustness, cost-effectiveness, high selectivity, high sensitivity, and on-site detection. Nanomaterials integrated into biosensors have small sizes, high electrical and thermal conductivity, biocompatibility, and high surface area, making biosensors more selective, and sensitive and an increase in performance is observed [4]. Graphene is a 2-dimensional (2D) nanomaterial consisting of carbon atoms in a honeycomb lattice structure. Graphene Oxide (GO) is a graphene derivative obtained during the oxidation of graphite. GO, is widely used in the detection of various biomolecules with its superior properties such as providing a large surface area, being biocompatible, having a stable structure, and having a high electron transfer rate [5].

In this study, a novel label-free electrochemical nanogenosensor was developed for the determination of *Escherichia coli* bacteria. The biosensing platform was built graphene oxide-modified disposable pencil graphite electrodes (GO-PGEs). Immobilization of the *E. coli* DNA probe was achieved onto the GO-PGEs surface. Hybridization was performed with denatured PCR amplicons of *E. coli*. The hybridization between the target sequences and the probe was analyzed by Electrochemical Impedance Spectrometry (EIS) technique. The nanogenosensor was optimized for higher specificity and sensitivity. This platform can be extended further to develop genosensors for the detection of various other microorganisms having applications in environmental, food industries, and medical applications.

Keywords: Electrochemical Nanogenosensor; Graphene Oxide; Pathogenic Microorganisms; *E. coli;*

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Multi-walled Carbon Nanotubes Modified Electrochemical DNA Biosensor Design for etermination of the Interaction between DNA and Favipiravir Drug Used in the Treatment of COVID-19

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Favipiravir (FAV) was one of the drugs used in patients infected with Sars-CoV 2 during the pandemic. FAV had been prescribed to apply for five days by patients.[1][2] Electrochemical biosensors are devices to provide fast, selective, convenient and low detection limits which are used in several fields such as analyzing drug-DNA interactions, observing electrochemical features of drugs, DNA damage research, DNA-based determination of genetic disease, and anti-cancer drug effectiveness.[3] In this study, the electrochemical DNA-based biosensor was designed for determination of FAV and DNA interaction by using bare and multiwalled carbon nanotube (MWCNT) contained pencil graphite electrode (PGE) for the first time. In addition, both the tablet form and the standard form of FAV were used in the experiments. In this regard, some sort of parameters such as concentration, interaction time, presence and absence of nanomaterials and scan rate were investigated by using differential pulse voltammetry (DPV) and cyclic voltammetry (CV). As a result, it has been determined the difference in DNA signals that both forms of the drug interact with DNA.

Keywords: Favipiravir; Nanomaterial; DNA-based biosensor; Electrochemistry

Acknowledgements
The authors are thankful to the Scientific and Technological Research Council of Türkiye (TUBITAK) for this project, which was supported within the scope of TUBITAK-2209-A UNIVERSITY STUDENTS RESEARCH PROJECTS SUPPORT. Project Name: Nanomaterial Based Electrochemical DNA Biosensor Design to Determine the Interaction Between Favipiravir Drug Used in the Treatment of COVID-19 and DNA. Project Number: 1919B012200707

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Multisensing Portable Tool Based on Novel Fullerenol Derivatives for Health Status Monitoring

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The application of nanotechnology for (bio)electronics and biosensing tools development led to various applications in clinical diagnostic, allowing miniaturization and enabling their integration in portable devices, through *on site*, *in situ* and *on-line* determinations [1]. Development of biofunctional, flexible, conductive fullerenol-based (FL) hybrid nanomaterial was achieved by functionalization of FLs with active functional groups (thiol/amine/carboxyl) providing a favorable microenvironment for immobilization of both enzymes and aptamers, offering new opportunities for highly specific determinations. Integration of these components into a multisensing portable tool for real-time monitoring of biological and clinical markers (glucose, lactate, cortisol, H_2O_2, etc) rapidly achieved results with limited resources and minimum need of skilled personnel.

Biosensors were obtained by functionalization of multisensor template (SPE) with amino acid-based FL derivates, polymers such as agarose-based hydrogels (HG), chitosan (CS) and sol-gel (SG) networks together with the redox mediator Prussian Blue (PB) [2]. The enzymes glucose (GOx) and lactate (LOx) oxidases and cortisol-specific aptamer were immobilized on functionalized FL layers for the selective detection of the clinical biomarkers. The CV studies showed enhanced electrocatalytic activity of the FL-based (bio)sensors towards H_2O_2, at an applied potential of +40 mV, within a linear range of 8−850 µM, and a sensitivity of 22.35 $mA \cdot M^{-1}$. The structural properties and enhanced electric conductivity of the FL-based nanomaterials led to good analytical performances, allowing a selective determination of glucose and lactate with sensitivities values of 1.09 $mA \cdot M^{-1}$ for glucose and 3.21 $mA \cdot M^{-1}$ for lactate. Cortisol detection was achieved by electrochemical impedance spectroscopy using covalently bound aptamers on functionalized-FL. The developed FL- based (bio)sensors facilitate the simultaneous sensitive detection of multiple clinical biomarkers from biological samples such as sweat or saliva, with enhanced stability, sensitivity and selectivity.

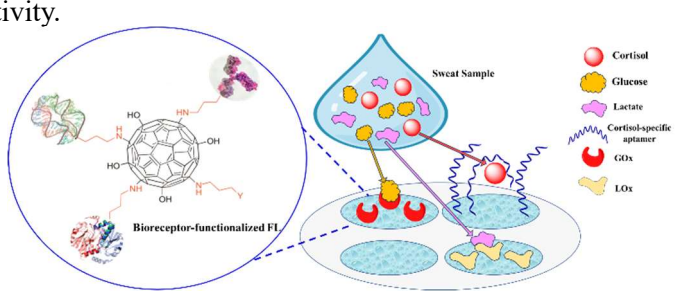

Figure 1. Multisensing of clinical biomarkers using FL-based portable electrochemical tool.

Keywords: hydrogels; nanocomposites; fullerenol; biosensors

Acknowledgements
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Biosensing Approaches in the Development of Innovative Opto-Electrochemical Portable Tools for Food, Clinical and Environmental Applications

Ana-Maria Gurban[1]*, Lucian-Gabriel Zamfir[1], Petru Epure[2], Mihai Mitrea[3], Cristina Nistor[1], Iuliana Răut[1], Mariana Constantin[1], Cristina Firincă[1], Cătălina Gîfu[1], Cristian Petcu[1], Bogdan Trică[1], Maria-Luiza Jecu[1], Mihaela Doni[1]

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Innovative opto-electrochemical platforms have been developed and optimized for the detection of biologically important analytes, biogenic amines (BAs), such as putrescein, histamine and histidine, by integration of specific aptasensors into miniaturized, portable systems, for the earliest possible determination, with increased sensitivity and specificity of the level of contamination of different samples (biological fluids, food or soil). The BAs are a group of low molecular weight organic compounds generated from the biochemical or microbial degradation of amino acids, present in all eukaryotic cells, including nervous system cells, with harmful effects for humans [1]. The accumulation of BAs in food usually occurs due to the microorganisms that possess amino acid decarboxylase activity [2], while in plants, BAs play an important role for the plant grows and development, their concentrations increasing under environmental stressor factors. In the human body, they can have both positive and negative effects, depending on their origin, type and dose [1,2].

For the design and development of the opto-electrochemical aptasensors, commercial screen-printed carbon paste electrodes (SPE) on ceramic (Dropsens) and paper (Italsens) support were modified with different synthesized nanomaterials and metal nanoparticles. The obtained sensors were characterized by electrochemical studies and morpho-structural analyzes to evaluate the distribution and uniformity of the nanomaterial layer on the active surface of the working electrode. The aptasensors developed by using gold nanoparticles and specific aptamers for histamine and histidine were integrated in portable miniaturized opto-electrochemical tool allowing the sensitive and specific detection of histamine and histidine by electrochemical impedance spectrometry (EIS) and electrochemiluminescence (ECL). The ECL determinations were performed in a solution containing 100 mM luminol and the co-reactant hydrogen peroxide, after incubation with different concentrations of biogenic amines. The aptasensors are placed in the ECL cell, and a volume of 300 µL of a mixture of 100 mM luminol and 10 mM H2O2 is deposited on their surface, and the measurements in ECL and linear sweep voltammetry (LSV) are performed. For the EIS measurements, the value of the charge transfer resistance increases with the concentration of biogenic amine from 0.1 to 5 ng/mL, and at concentrations higher than 10 ng/mL a saturation of the signal is observed as well as a decrease at higher concentrations due to the "hook" effect.

Tests for the determination of histamine and histidine in different food samples (chicken meat, fish, cheese, salami, sausages, von and beer) were carried out with high accuracy, due to the degree of miniaturization and portability of the developed system, and especially due to the combined detection method, opto-electrochemical. These developed opto-electrochemical analytical platforms can be used for a number of other important compounds in food, environment or of clinical importance, such as drug residues, hormones, pesticides, etc., being able to control and monitor the quality of life.

Keywords: aptasensors; biogenic amines; electrochemiluminescence; nanomaterials

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Preparation of Imprinted Plasmonic Biosensors in Factor VIII Detection

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Biosensors play a crucial role in personalized treatment, diagnosis, and disease monitoring.[1] In particular, for diagnosis and treatment, theoretical foundations of treatment plans for rare diseases and hereditary bleeding disorders cannot be universally applied to the entire population.[2] The high instrumental characteristics of laboratory tests and the need for experienced professionals weaken the patient-doctor communication foundation, as these requirements cannot be provided to the entire population. The creation of fingerprints of clotting proteins on imprinted polymers for hereditary bleeding disorders and hemophilia is expected to enable the measurement of critical diagnostic and treatment data in real-time and without spatial dependency.[3-5]

This approach, which we anticipate will become an important data source model for personalized medicine and treatment processes globally, will support doctors' interpretative abilities and contribute to the patient's daily life positively, thus not lagging in producing added value. For this purpose, the plasmonic biosensors are prepared using imprinted nanoparticles for selective and sensitive detection of Factor VIII. The imprinted nanoparticles are first synthesized and characterized using size and transmission electron microscopy analysis and then used for preparation of imprinted plasmonic biosensor. Following the several characterization studies including atomic force microscopy and contact angle of plasmonic biosensors, they used kinetic, selectivity, and reusability analysis for real-time Factor VIII detection.

Keywords: Personalized Treatment, Rare Diseases, Coagulation, Protein Detection, Molecularly Imprinted Polymers; Plasmonic Biosensor.

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A Reduced Graphene Oxide-Based Electrochemical Aptasensor for N-Nitrosamines Detection

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In July 2018, the US Food and Drug Administration (FDA) and the European Medicines Agency (EMA) announced the presence of a new class of carcinogenic impurities, NMDA and N-Nitrosodiethylamine (NDEA), in generic Active Pharmaceutical Ingredients (APIs) [1]. Therefore, it is essential to employ a specific and sensitive sensor system to qualify and quantify nitrosamine contamination observed in finished pharmaceutical products [2].

In this work, a facile and sensitive aptamer-based biosensor (aptasensor) for N-nitrosamines (NAs) detection was successfully developed using reduced graphene oxide (GO) electrodes. Firstly, aptamer arrays selectively and sensitively capable of recognizing N-nitrosodimethylamine (NDMA), N-nitrosodiethylamine (NDEA) and N-nitroso-N-methyl-4-aminobutyric acid (NMBA) molecules were developed by the method of Graphene Oxide Systematic Evolution of Ligands by Exponential Enrichment (GO-SELEX). Secondly, the reduced (rGO) patterns were produced by stamping patterned graphene oxide (GO) on polyethene terephthalate (PET) substrates using the wax-printing method. Finally, the prepared graphene-based patterns were modified by aptamers and used as an working electrode for the electrochemical determination of nitrosamines.

At the end of each SELEX cycle, the target binding rate was determined for NDMA, NDEA and NMBA by fluorescence labeling method using 0.1-250 µM of analyte with 1.0 µM aptamer. For the morphological characterization of GO was performed by scanning electron microscopy (SEM), and atomic force microscopy (AFM) techniques. The selective determination of nitrosamines was carried out by electrochemical impedance spectroscopy (EIS) methods. Aptasensors were prepared using specific aptamers for three different nitrosamines at with the aptamer concentration range of 0.1 – 1.5 µM. Then, aptasensor optimization was carried out with the two different nitrosamine concentrations ($4x10^{-6}$ M and $8x10^{-6}$ M).

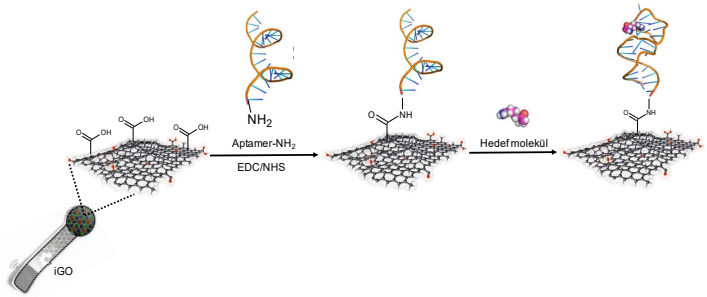

Figure 1. Preparation of aptasensors on reduced graphene oxide surfaces

Keywords: Nitrosamines, aptamer, flexible graphene-based electrodes

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This study was supported by The Scientific and Technological Research Council of Turkey with grant number as TUBITAK-KBAG-122Z411.

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Electrochemical and Spectrofluorimetric Investigation of the Interaction Between dsDNA and 2,6-Diisopropylphenol

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2,6-Diisopropylphenol, known as propofol, is a potent intravenous hypnotic drug frequently used to maintain anesthesia and provide sedation in intensive care units. Propofol also has notable immunomodulatory, anti-inflammatory, and antioxidant properties [1]. In veterinary medicine, propofol has been widely developed for use, especially in dogs, and is more frequently used for cats in Europe [2]. Therefore, examining the interaction between DNA and anesthetic drug is essential for understanding how anesthetic drugs affect DNA in organisms. An electrochemical biosensor is an instrument that integrates a biological sensing component with an electrochemical transducer to analyse specific biological substances. These sensors are widely utilized in medical diagnostics, environmental monitoring, food safety, and biotechnology because of their high sensitivity, specificity, and quick response rates [3]. The purpose of this research is to investigate the effect of propofol on DNA by differential pulse voltammetry (DPV) using two different interaction methods: at the dsDNA-electrochemical biosensor surface and in bulk incubated solution.

Electrochemical experiments were performed using the AUTOLAB-PGSTAT 30 electrochemical analysis system. The electrochemical cell with a 3.0 mm diameter glassy carbon (GC) working electrode, a platinum wire counter electrode, and an Ag/AgCl (3 M NaCl) reference electrode were used. Propofol and calf thymus dsDNA supplied by DEVA holding A.S. and Sigma-Aldrich respectively. They were used in the experiments with propofol stock solution of 358.56 ppm prepared in ethanol and dsDNA stock solution of 500 ppm prepared in ultra-pure water and both stored at +4 °C. The supporting electrolyte was pH 4.68 acetate buffer solution. In bulk incubation procedure, 100 ppm ct-dsDNA and propofol (in the range of 7.17 - 17.93 ppm) in solution form were mixed in pH 4.68 (0.1 M acetate buffer), and then incubated at room temperature. In dsDNA-electrochemical biosensor procedure, the multi-layer ct-dsDNA-modified electrode was prepared by depositing three drops of 5 µL each containing 50 ppm ct-dsDNA on the GCE surface each time. After the ct-dsDNA solution was applied onto the electrode surface, it was dried at 35°C, and the process was repeated for subsequent layers. After cool it down, the dsDNA-modified electrode was immersed in 17.93 ppm propofol solutions prepared in 20% ethanol and was analysed by DPV method.

The differences between the peaks of the adenine and the guanine before and after the interaction of propofol were found to be directly proportional to the increase in the concentration of propofol. In bulk incubated solution, after interaction with 17.93 ppm propofol, the guanine and adenine signals were almost decreased by 100 to 22%. At dsDNA biosensor, after interaction with propofol, the peak currents of guanine and adenine were almost decreased by 100 to 34.32 and 17.59%. The interactions between propofol-dsDNA was further studied by spectrofluorimetry at different temperature range as well.

This interaction studies by electrochemically and spectrofluorimetrically offer the opportunity to know about both the effects of drugs in DNA structure and mechanism of interaction.

Keywords: Biosensor; voltammetry; DNA; propofol

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Investigating the Direct Electrochemical Detection of 5-Hydroxymethylcytosine with Reduced Graphene Oxide Modified Pyrolytic Graphite Electrodes in Biological Samples

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Methylation is an important regulatory mechanism that controls gene function and activity without altering DNA and RNA sequences. DNA methylation has become one of the most studied epigenetic marks [1]. 5-hydroxymethyl cytosine (5hmC) is the modification that results from DNA methylation that plays an important role in epigenetic regulation. 5hmC is formed as an intermediate in active DNA demethylation and has an important place in various biological processes, especially neurodevelopment and cancer biology. 5hmC, formed by the conversion of 5-methylcytosine (5mC) by TET (Ten-Eleven Translocation) enzymes, plays a critical role in regulating gene expression and reprogramming epigenetic information [2].

5hmC levels, which have an important place in cancer biology, vary in many types of cancer. For example, decreased 5hmC levels have been observed in various solid tumors and hematological cancers. These changes can be used as potential biomarkers for early diagnosis and prognosis of cancer. 5hmC analysis is crucial for early diagnosis of cancer and monitoring treatment responses. Additionally, it may help determine the prognosis of different diseases, such as neurodegenerative diseases, such as Parkinson's and Alzheimer's, and various autoimmune diseases. 5hmC analysis helps understand the mechanisms of epigenetic changes and determine the effects of these changes on gene expression, which may contribute to the development of new treatment strategies [3].

In this study, a rapid and sensitive voltammetric method was developed for the first time for the determination of 5-hydroxymethylcytosine (5hmC) in human urine. The method was developed by applying graphene oxide (GO) by dropping it on a pyrolytic graphite electrode (PGE) and subsequent electrochemical reduction of graphene oxide (ErGO/PG) in a pH 7.00 phosphate buffer solution. The optimal number of reduction and activation cycles were determined to be 15 and 45 consecutive cycles, respectively. Stripping conditions and square wave voltammetry parameters were optimized in pH 7.00 phosphate buffer. The calibration curve showed a linear range between 0.60 and 4.00 ppm in human urine with a satisfactory recovery value of 101.21%. Additionally, this method was also successfully applied to the calf thymus-DNA sample.

Keywords: Hydroxymethylcytosine, voltammetry, graphene oxide, epigenetic DNA

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Investigation of Ritonavir-DNA Interaction by Spectrophotometric and Electrochemical Methods

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Ritonavir ($C_{37}H_{48}N_6O_5S_2$) is a protease inhibitor commonly used in the treatment of HIV among adults and children. As a part of the protease inhibitor class, its primary role is to inhibit HIV protease, an enzyme vital for the replication of the virus. Beyond its direct antiviral effect, ritonavir is known to enhance the bioavailability of other antiretroviral drugs through the inhibition of cytochrome P450-3A4, a liver enzyme that metabolizes drugs. This capability extends its use to combination therapies for treating conditions like Hepatitis C [1]. Understanding the interaction between ritonavir and DNA is critical, especially in assessing the potential genotoxic effects of drugs, which may include mutations or DNA damage. This research is crucial for ensuring the long-term safety of ritonavir, especially for patients on extended treatment regimens. Furthermore, understanding ritonavir's molecular binding can contribute to the development of safer and more effective therapeutic strategies, help predict potential long-term side effects, and potentially uncover new therapeutic targets. [2]. UV-spectrophotometry was employed to investigate DNA-ritonavir interactions. In these experiments, DNA stock solutions were prepared using calf thymus DNA (ct-DNA) at a concentration of 500 ppm in ultra-pure water. In comparison, ritonavir stock solutions were papered at 6000 ppm in ethanol. Measurements were conducted at room temperature using a 25 ppm ct-DNA solution prepared in a 3 ml 1:1 ethanol and water mixture. As a result of spectrophotometric measurements conducted with measurement solutions prepared in the range of 19.93 ppm to 626.87 ppm using a 6000 ppm ritonavir stock solution resulted in a linear increase in DNA peak levels from 102.1% to 217.6% compared to the measurement solution containing ct-DNA alone, and the peak wavelength shifted from 260.4 nm to 259.8 nm. Time-based studies at different times (between 0 and 24 hours) and thermodynamic studies at different temperatures (4°C, room temperature and 35°C) were performed for spectrophotometric measurements. Furthermore, the findings from spectrophotometric studies were compared with those obtained using electrochemical DNA incubation methods using a pH 4.70 acetate buffer solution, a 100 ppm DNA solution, and various concentrations of ritonavir.

Keywords: Ritonavir, UV-spectrophotometry, Electrochemistry, DNA.

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An Electrochemical Sensor Based on ZnO Nanoparticle-Assisted Molecularly Imprinted Polymer for Highly Sensitive and Selective Determination of Clozapine

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Clozapine (CLO) is an atypical antipsychotic drug indicated for the treatment of schizophrenia. Schizophrenia is one of the most challenging mental illnesses, and patients may experience cognitive, emotional, and behavioral disorders as well as suicidal tendencies [1,2].

In this study, a molecularly imprinted polymer (MIP)--based electrochemical sensor was developed for the quantitative analysis of CLO. The ZnO nanomaterial-supported MIP-based electrochemical sensor designed using the thermal polymerization method was developed on a glassy carbon electrode (GCE) using CLO as the target molecule and trans-3-(3-Pyridyl)acrylic acid (3,3-TA) as the functional monomer. Surface morphology and electrochemical characterizations were performed using scanning electron microscopy (SEM), cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS) methods.

The differential pulse voltammetry (DPV) technique was successfully applied with high sensitivity and accuracy in the determination of CLO in standard solution, real human sample, and tablet dosage form using 5.0 mM $[Fe(CN)_6]^{3-/4-}$ as a redox probe. The limit of detection (LOD) values for the standard solution and real human serum sample were calculated as 2.9×10^{-11} M and 6.01×10^{-12} M, respectively. The sensor's selectivity was evaluated using common interfering substances. Additionally, the performance of the developed sensor was compared and verified using the LC-MS/MS method.

Finally, this is the first MIP-based electrochemical application for CLO determination in the literature.

Keywords: Clozapine; Molecularly Imprinted Polymers; Electrochemical sensors.

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Production of a Molecularly Imprinted Polymer-Based Sensitive and Selective Electrochemical Sensor Using Prussian Blue Nanoparticles for the Specific Recognition and Determination of Chloroquine Phosphate

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Malaria, a major infectious disease that affects the entire world, is spread by the bite of infected mosquitoes, which carry malaria parasites in their salivary glands. Chloroquine phosphate (CHL), a commonly used antimalarial drug, is being used to treat malaria [1]. In the present work, molecularly imprinted polymer (MIP)-based electrochemical sensors were produced using Prussian blue nanoparticles (PBNPs) and Prussian blue analogue nanoparticles (PBANPs), prepared using green synthesis procedures to increase the active surface area and porosity of the glassy carbon electrode (GCE) surface. For this purpose, various types of nanoparticles containing polyethyleneglycol-amine (PB@PEG-NH_2) and different polyethyleneimines (PBA@PEI-273 and PBA@PEI-210) were used. Along with other MIP components, 2-acrylamido-2-methyl-1-propanesulfonic acid (AMPS) was chosen as the functional monomer. The developed CHL/AMPS/PB@PEG-NH_2/MIP-GCE sensor was evaluated in detail using various analytical techniques, including energy dispersive X-ray analysis (EDX), scanning electron microscopy (SEM), cyclic voltammetry (CV), and electrochemical impedance spectroscopy (EIS). The technique of indirect measuring (5.0 mM $[Fe(CN)_6]^{3-/4-}$ solution) was used to determine CHL, exhibiting linear response in the range 0.25 – 1.75 pM, and limits of detection (LOD) and quantification (LOQ) of 33.59 and 111.85 fM, respectively, in standard solutions and diluted human serum. The sensor's reliability was demonstrated by its repeatability and reproducibility, which ranged from 0.97% to 2.42%. The sensor's excellent selectivity was successfully demonstrated in the presence of substances with a structure similar to CHL.

Keywords: Malaria; Chloroquine phosphate; Prussian blue nanoparticles; Molecularly imprinted polymer; Electrochemical sensor; Drug analysis

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Detection of Roxadustat in Dosage Forms and Biological Samples: A Highly Sensitive Electrochemical Approach by Using Glassy Carbon Electrodes

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Roxadustat (ROX) is a new therapeutic agent indicated for anaemia associated with chronic kidney disease (CKD). As an oral hypoxia-inducible prolyl hydroxylase inhibitor (HIF-PHI), it plays an important role in the regulation of erythropoiesis, the process by which red blood cells are produced.[1]. This work is the first to use a glassy carbon electrode (GCE) in an electrochemical method to determine ROX in a standard solution and commercial serum sample. The pH and scan rate effects were assessed, in addition to determining ROX in the electrochemical oxidation behavior. Additionally, the electrochemical oxidation process of ROX was determined by cyclic voltammetry (CV). The results found that the GCE electrode was also diffusion-controlled and irreversible, and the possible oxidation mechanism was investigated and clarified in detail. The standard calibration curves were linearly obtained in the concentration ranges of $2 \times 10^{-6} - 1 \times 10^{-4}$ M, and the commercial human serum calibration range was $1 \times 10^{-6} - 2 \times 10^{-5}$ M. The proposed sensors were successfully utilized for the quantification of ROX in pharmaceutical dosage forms and biological samples with excellent recovery and precision results. The limit of detection (LOD) values in standard and commercial serum samples in 0.5 M H_2SO_4 on GCE were calculated as 2.44×10^{-7} and 2.75×10^{-7} M, respectively. The proposed methods were also evaluated in the presence of some potential interference compounds and ions.

Keywords: Roxadustat; Electrochemistry; Voltammetry; Method validation; Drug analysis

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A Novel Electrochemical Sensing Platform Combined with Molecularly Imprinted Polymer and VMXene NFs Composite for Highly Selective and Sensitive Determination of Methionine

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The complex clinical condition known as acute renal failure (ARF) is now recognized to be better described by the term acute kidney injury (AKI). The vast range of this illness, which encompasses patients with a temporary rise of serum creatinine to those who eventually require dialysis, is better defined by the usage of this new phrase. Furthermore, the metabolic profiles of serum samples from seventeen hospitalized patients who had just received a diagnosis of AKI were contrasted with those of age-matched individuals who had normal kidney function. Compared to healthy subjects, patients with AKI had lower serum levels of arginine and various lysophosphatidyl cholines and higher levels of acylcarnitines and amino acids (methionine (MET), homocysteine, pyroglutamate, asymmetric dimethylarginine, or ADMA), and phenylalanine [1]. In this work, a nanoparticle-supported molecularly imprinted polymer (MIP)-based electrochemical sensor was designed for highly sensitive and selective determination of MET. For this purpose, sensor performance was tested using different nanomaterials, such as vanadium-modified MXene (VMXene), vanadium-modified MXene nanoflowers (VMXene NFs), niobium-modified MXene (NbMXene), and niobium-modified MXene nanoflowers (NbMXene NFs). 3-thienylboronic acid (3-TBA) as the functional monomer, along with other MIP components, was used. Both morphological and electrochemical characterization of the polymer film (MET/3-TBA/VMXene NFs/MIP-GCE) was examined using a scanning electron microscope (SEM), energy dispersive X-ray analysis (EDX), cyclic voltammetry (CV), and electrochemical impedance spectroscopy (EIS). Under optimized conditions, the nanomaterial-assisted MIP-based electrochemical sensor demonstrated the ability to determine MET in the linear working range of 0.25–2.5 pM for a standard solution and commercial serum samples with LODs of 35.12 fM and 42.33 fM, respectively. In addition, the correlation coefficients (r) for the standard solution and commercial serum samples, respectively, were 0.997 and 0.998, indicating good linearity for MET. The suggested modified sensor showed notable sensitivity and selectivity for the quick determination of MET in commercial serum samples. The sensor developed in the presence of amino acids with a similar structure to MET showed excellent selectivity.

Keywords: Methionine; Acute kidney injury biomarker; Vanadium-modified MXene nanoflower; Molecularly imprinted polymer; Electrochemical sensor; Photopolymerization

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Benzotriazole Decorated Conductive Polymeric Layer for the Selective Electrochemical Determination of Heavy Metal Ions

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Heavy metals are some of the most challenging pollutants due to their toxic and non-biodegradable nature and their bioaccumulation in ecological systems [1]. In this study, a new functional monomer, 2,3-(N-benzotriazole)thiophene was synthesized and utilized to develop functional conductive polymeric layer. Meanwhile, nickel(II) and cobalt(II) ions were chosen as model heavy metal ions to be determined electrochemically [2]. Herein, conductive polymeric layer was deposited on the screen-printed electrodes (SPEs) via electro-polymerization of 2,3-(N-benzotriazole)thiophene in the presence of ethylenedioxythiophene (EDOT) as a comonomer and lithium perchlorate as a dopant. Electrochemical characterization was conducted by cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS). Surface morphology was characterized by atomic force microscopy (AFM), and attenuated total reflection Fourier transform infrared spectrophotometry (ATR FT-IR). Sensor performance for metal ions was evaluated while varying metal ion concentration in the range of 1-100 ppm from their singular aqueous solutions [3]. After that, double mixtures of metal ions aqueous solution were applied to the sensor system to analyze the possibility of simultaneous determination of each metal ion. In conclusion, the functional monomer might be classified to develop functional conductive polymeric layer for determination of not only heavy metal ions but also other complementary molecules via easy, repeatable, cost-friendly, and user-friendly polymerization method.

Keywords: Heavy metal ions, conductive polymeric layer, electrochemical sensor, differential pulse voltammetry

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Molecularly Imprinted Electrochemical Sensor for Selective Detection of 2,4-Dinitrotoluene

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Molecularly imprinted polymer is a kind of polymerization strategy to design selective polymeric interface for not only separation sciences but also sensing applications [1]. 2,4-Dinitrotoulene is frequently used as a plasticizer, deterrent coating, and burn rate modifier in propellants (e.g., smokeless gunpowders). As it is carcinogenic and toxic, modern formulations tend to avoid its use [2]. Before the synthesis of sensitive and selective 2,4-DNT imprinted poly(pyrrole-co-pyrrole carboxylic acid) [poly(Py-co-PyCOOH)] film on the graphite electrode surface for 2,4-DNT determination, the electrode surface was functionalized with a graphene oxide (GO) layer serving as support. In the synthesis process of GO, the sp^2 structure of the graphite layers is disrupted and different oxygen-containing functional groups are obtained through covalent, non-covalent (π-π or hydrophobic) and/or ionic interactions, which form active bonding points for electrochemical materials such as carboxyl, hydroxyl or epoxy groups [3,4]. In the next step, molecular imprinting-based electropolymerization of 1 mM Py-COOH / 4 mM Py monomers was carried out in the presence of 2,4-DNT in PBS (pH: 7.4) buffer containing 0.1 M $LiClO_4$ as a dopant [5,6]. EIS measurements taken in the 0.5-100 ppm concentration range revealed that the developed single sensor system could measure with 85% linearity.

Keywords: 2,4-Dinitrotoluene, conductive polymeric layer, electrochemical sensor,

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A Novel Electrochemical Sensing with Molecularly Imprinted Polymer for Highly Selective and Sensitive Determination of Anticancer Drug

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Lung cancer is the most common type of cancer worldwide. Unfortunately, the survival rate is mostly very low at all stages. The most common lung cancer type is non-small cell lung cancer (NSCLC) [1]. Erlotinib (ERL) is a drug which is used for the treatment of lung cancer. It is a tyrosine kinase inhibitor which prevents the growth of cancer cells. ERL is approved by the FDA for the treatment of locally advanced or metastatic NSCLC. A new nanomaterial-supported molecularly imprinted polymer (MIP)-based electrochemical sensor was fabricated for determination of ERL. By using ZnQ nanoparticles, the number of regions and effective surface area were increased. The polymeric film was obtained using 3-aminophenyl boronic acid (3-APBA) as a functional monomer, ethylene glycol dimethacrylate (EGDMA) as a cross-linker, 2-hydroxyethyl methacrylate (HEMA) as basic monomers, and 2-hydroxy-2-methyl propiophenone as initiator. The developed 3-APBA/ERL/ZnQ@MIP-GCE was morphologically characterised using SEM and electrochemically using electrochemical impedance spectroscopy (EIS) and cyclic voltammetry (CV) measurements. The 3-APBA/ERL/ZnQ@MIP-GCE sensor exhibited a linear response ranging from 1.0×10^{-13} M to 1.0×10^{-12} M with a limit of detection (LOD) and limit of quantification (LOQ) of 3.22×10^{-14} M and 1.07×10^{-13} M, respectively. In addition, the correlation coefficients (r) for the standard solution and commercial serum samples, respectively, were 0.997 and 0.998, indicating good linearity for ERL. The developed MIP sensor was used for ERL detection in commercial serum samples and tablet form. In addition, highly selective and sensitive for the determination of ERL were achieved in this study.

Keywords: Erlotinibe; Lung cancer; ZnQ nanoparticles; Molecularly imprinted polymer

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Development of a Molecular Imprinted Polymer Sensor Designed by Electropolymerization for Anticancer Drug Detection

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Poly adenosine diphosphate (ADP)-ribose polymerase (PARP) inhibitors have been approved for use in the maintenance treatment of ovarian cancer caused by BRCA mutations. Niraparib (NPB) is an active drug substance in this particular group [1,2]. In this study, an electrochemical analysis was conducted using a molecularly imprinted polymer (MIP) based sensor with the goal of achieving lower detection limits for determining NPB. The primary focus of this study is to attain high selectivity and sensitivity in determining NPB utilizing a molecularly imprinted polymer (MIP) based electrochemical sensor. The development of the MIP sensor involved the use of electropolymerization on a glassy carbon electrode (GCE) with NPB serving as a template molecule, along with 3-amino phenyl boronic acid (3-APBA) and aniline (AN) as functional monomers. The electrochemical behavior of the resulting sensor was analyzed using various techniques, including differential pulse voltammetry (DPV), cyclic voltammetry (CV), and electrochemical impedance spectroscopy (EIS). Under optimal experimental conditions, the newly developed 3-APBA/AN/NPB@MIP-GCE sensor demonstrated excellent analytical results for the detection of NPB. The sensor exhibited a linear response ranging from 2.0×10^{-12} M to 1.0×10^{-11} M, with a limit of detection and quantification of 4.08 10^{-13} M and 1.36 10^{-12} M, respectively. Additionally, the sensor was tested on commercial serum samples, yielding excellent results and recoveries ranging from 100.23% to 101.08%. The designed sensor showed excellent electrochemical response for NPB and demonstrated the ability to specifically identify NPB compared to structurally similar drugs, such as its metabolite, Axitinib, Pazopanib, Haloperidol, Niclosamide and Pantoprazole. Moreover, the sensor's response to interference from common substances found in biological fluids, including K^+, Na^+, Ca^{+2}, Cl^-, DOP, AA, UA, and PAR, was also investigated.

Keywords: Molecularly imprinted polymer, electropolymerization, voltammetry, anticancer drug.

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Investigation of the Effect of BDT-Based Conjugated Polymer Nanoparticles for Biosensing Applications

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Conjugated polymers (CPs) have appealing optical and electrochemical features due to their delocalized π-electron cloud across the chain, which is formed by alternating σ and π bonds along their backbone. CPs with an extended π-electron system have found extensive usage as constituents in many applications, such as organic photovoltaic cells, biosensors, field-effect transistors, and electrochromic devices [1,2]. Excellent environmental stability, strong conductivity, low oxidation potential, transparency, biocompatibility, simplicity of fabrication, economical cost, and narrow band gap (Eg, 1.6 eV) are only a few of their special qualities [3]. These enhanced qualities have led scientists to utilize CPs in the development of highly successful biosensing platforms [2, 4]. Also, CPs, by directly connecting the enzyme to the electrode surface, enhance the electrical connection between the electrode surface and the enzyme's redox center [5]. Monomers such as benzothiophene (BDT) have a substantial effect on the characteristics of CPs, including strong thermal stability and conductivity. The creation of conjugated polymer nanoparticles (CPNPs) and the manufacture of water-soluble CPs by replacing side chains with hydrophilic functional groups have received great attention in many types of applications [6]. In this study, primarily two different BDT-based CPs were synthesized via stille coupling reaction and characterized with specific methods. CPNPs were synthesized via the reprecipitation method and characterized using dynamic light scattering (DLS), fluorescence, and UV-Vis spectroscopy techniques. The synthesized and characterized CPNPs were subsequently used to design an electrochemical biosensor. CPNPs were individually immobilized on the electrode surface to conduct biosensing tests. Then, a comparison was made between the two nanoparticles' biosensor responses that were created for the target analysis.

Keywords: Conjugated polymers, conjugated polymer nanoparticles, biosensor

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Investigation of Glucose Sensing Ability of Ni-Based Metal Organic Frameworks

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Metal-organic frameworks (MOFs), porous coordination polymers, are crystalline porous materials constructed from metal ions/clusters and organic linkers. [1] MOF-based materials have excellent structural and compositional properties, making them preferable for various applications, such as sensors, drug delivery, gas storage and separation, and catalysis. [2] It is vital for diabetics to use noninvasive, quick blood glucose detection technologies. Among electrochemical glucose sensors, enzyme-based biosensors present high sensitivity, specificity, and a wide response range. [3] The synthesized MOF was effectively used for selective and sensitive glucose detection because of the Ni-MOF architecture's high-efficiency and quick synthesis method. Cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS), and scanning electron microscopy (SEM) were used to evaluate the electrochemical and surface characteristics of the biosensor, respectively. The results demonstrate that Ni-MOF/PEDOTNPs/GOx shows more successful electrocatalytic activity for glucose oxidation than Ni-MOF manufactured using standard methods. The Ni-MOF/PEDOTNPs/GOx glucose biosensor demonstrated remarkable performance, including high sensitivity (120.606 µA $mM^{-1}cm^{-2}$) and low detection limit (13.96 µM). The Ni-MOF/PEDOTNPs/GOx biosensor enables us to reliably analyze glucose levels in beverage samples. The laser synthesis of Ni-MOF significantly improved the performance of the electrochemical biosensor in practical applications. The study describes a new synthesis process for Ni-MOFs, which will add to the list of known synthesis pathways for sensor and electrical applications.

Keywords: Electrochemical sensor; glucose sensing; Ni-based metal organic frameworks.

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Development of a Carbon-Based Sensor Using Voltammetry Techniques for the Determination of Daptomycin and Application in Different Environmental Samples

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Daptomycin is effective in treating infections caused by antibiotic-resistant Gram-positive pathogens [1]. Daptomycin is often prescribed in association with a partner drug to increase its bactericidal effect and to prevent the emergence of resistant strains during treatment [2]. The widespread use of the active ingredient daptomycin also reveals the problem of pollution in environmental samples. Therefore, rapid and sensitive analytical methods for daptomycin in these environmental samples are needed. In this study, a sensitive, selective, and applicable electrochemical method was developed using a bare glassy carbon electrode (GCE) and newly developed multi-walled carbon nanotubes/titanium dioxide nanoparticles/ titanium dioxide nanoparticles modified GCE (MWCNT/TiO_2/TiO_2/GCE) sensor for the determination of daptomycin using voltammetric methods. The surface characterization of the developed sensor was examined by scanning electron microscopy (SEM) and SEM-energy dispersive spectrometry (SEM-EDX). The electrochemical properties of the substance were investigated by cyclic voltammetry, and the determination of daptomycin was made by differential pulse and absorptive stripping differential pulse voltammetry techniques. Under optimized conditions, the linearity range was determined as 0.2-1.0 µM and 0.06-5.0 µM the bare electrode and MWCNT/TiO_2/TiO_2/GCE, respectively. The limit of detection (LOD) was calculated as 0.001 µM and 0.086 µM for bare electrode and MWCNT/TiO_2/TiO_2/GCE, respectively. The selectivity of the proposed sensor, for inorganic and organic substances that could affect daptomycin detection were investigated by interference studies. The accuracy of the methods proposed for the determination of daptomycin in different environmental samples (soil, tap water and natural spring water) was calculated as % recovery in recovery studies. Thus, for the detection of daptomycin, an important antibiotic drug, in environmental samples, a fast, reliable, cheap, environmentally friendly, sensitive, and highly selective sensor was developed for the first time, and a new analysis method was introduced in the literature.

Keywords: Daptomycin; voltammetry; sensor; electrochemistry

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Evaluation of the Electrochemical Behavior of the Janus Kinase Inhibitor Abrocitinib in Biological Samples Using Glassy Carbon and Boron-Doped Diamond Electrodes

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By specifically blocking JAK-1, abrocitinib (ABR) blocks signaling pathways linked to the atopic dermatitis etiology. Also, the possibility of negative side effects including neutropenia and anemia is eliminated by JAK1-specific inhibition [1]. For the first time, glassy carbon electrode (GCE) and boron-doped diamond electrode (BDDE) were used to create sensitive, quick, and environmentally friendly electroanalytical procedures for the detection of ABR. A thorough investigation was conducted utilizing both electrodes to examine the effects of pH, scanning rate, and supporting electrolytes on the peak current and potentials of ABR. Cyclic voltammetry (CV) was used to obtain irreversible anodic peaks at pH 3.7 in acetate buffer media, with GCE and BDDE showing peaks at 0.85 V and 0.91 V, respectively. Moreover, CV was used to ascertain the electrochemical oxidation process of ABR. Diffusion-controlled outcomes were observed at both electrodes. Furthermore, model compounds were used to study the mechanism of the oxidation process. The limit of quantifications (LOQ) was calculated as 8.52×10^{-7} and 6.09×10^{-7} M in commercial serum samples in pH 3.7 acetate buffer solution on GCE and BDDE, respectively. Additionally, linear concentration ranges for both GCE and BDDE were found to be between 2.0×10^{-6} M and 2.0×10^{-4} M. Accuracy and applicability of the voltammetric method was evaluated in spiked commercial serum samples by standard additions calibration curves with recovery ranging from 98.50% to 100.78%. Also, the selectivity study of the proposed techniques was evaluated in the presence of 1000-fold different ions and interfering compounds.

Keywords: Abrocitinib; Janus kinase inhibitor; Glassy carbon electrode; Boron-doped diamond electrode; Electrochemical behavior; Drug analysis

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Development of an Electroanalytical Method on a Boron-Doped Diamond Electrode for the Determination of the Anti-Cancer Drug Palbociclib in Biological Samples

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Palbociclib is a pharmaceutical compound designed by Pfizer specifically to treat breast cancer that is positive for hormone receptors (HR-positive) and negative for human epidermal growth factor receptor 2 (HER2-negative) [1]. Furthermore, palbociclib was the initial cyclin-dependent kinase 4/6 (CDK4/6) inhibitor to get approval for its application in cancer therapy [2]. In this study, a very sensitive and effective electrochemical method was developed to quantify Palbociclib precisely using differential pulse voltammetry at a boron-doped diamond electrode. A standard 10 ml three-electrode cell with a boron-doped diamond electrode, a platinum wire counter and an Ag/AgCl reference electrode were used in all studies. Electrochemical experiments were performed using a Methrom-AUTOLAB 204 potentiostat and NOVA 1.6 software. At BDDE, cyclic voltammetry and differential pulse voltammetry (DPV) were used for electrochemical experiments. Based on experimental results from studies of electrochemical characterization, it was concluded that diffusion controls the irreversible oxidation behavior of palbociclib in BDDE. For reference substance solution, human serum, and urine samples, anodic peak current showed a linear relationship within concentration ranges of 0.01–1 µM, 0.02–0.8 µM, and 0.02–0.8 µM in pH 2.0 phosphate buffer solution, respectively. At BDDE, DPV was used to make this finding. The standard drug solution, human serum, and urine samples have limits of detection of 2.28 nM, 2.93 nM, and 1.31 nM, respectively. The devised method's selectivity, accuracy, precision, repeatability, and reproducibility in all conditions were estimated and examined in order to validate it. Palbociclib was effectively analyzed in human urine and serum samples using this technique.

Keywords: Boron-doped diamond electrode (BDDE), Palbociclib(PALB), human serum sample, urine sample

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Advancing Melatonin Detection: A New Electrochemical Sensor Using Molecular Imprinting Nanotechnology

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Melatonin, essential for sleep-wake cycles and antioxidant defenses, is valuable in treating neurological disorders and viral infections [1,2]. Detecting melatonin accurately is challenging due to its low concentrations and complex biological environments. Metal nanoparticles, carbon-based electrodes, and conducting polymers each offer unique advantages for sensitivity, stability, and interference resistance. Carbon-based electrodes, especially multi-walled carbon nanotubes (MWCNTs), are favored for their cost-effectiveness, rapid electron transport, and biocompatibility [3]. Molecularly imprinted polymers (MIPs) are promising for selective sensing of target analytes due to their high specificity, stability, and reusability [4]. This article describes the fabrication process of molecularly imprinted polytoluidine blue o coated on MWCNTs modified glassy carbon electrode noted as MIP-PTBO/MWCNTs/GCE sensor and characterizes its electrochemical behavior toward MT detection. This research has implications for enhancing electrochemical sensing and could find use in clinical diagnostics and biological research, among other fields. The electrochemical measurements were performed with Palmsens 4 potentiostat controlled by PSTrace 5.8. The conventional cell is consisting of Pt wire as the counter electrode and glassy carbon (GCE, Ø = 3 mm, Basi MF-2012) for the working electrode. The Ag/AgCl electrode (3M saturated NaCl solution) was used as the reference for all measured potentials. The differential pulse voltammetry (DPV) was performed for the analysis using a potential sweep rate of 10 mV/s, a step potential of 0.008 V; modulation amplitude of 0.200 V; and pulse width of 50 ms. The morphology of the MIP was observed using scanning electron microscopy (SEM) with energy dispersive X-ray (EDX) analysis model ZEISS EVO 40 (Merlin, Carl Zeiss). Ultrasonic bath from J.P. Selecta (Barcelona, Spain) was used for MWCNTs sonication. ORCA version 5.0.1 software was utilized for computational studies. Solgar tablets and commercial serum were used for the application part. The optimized conditions were applied with DPV on the commercial human serum, were acquired and used for LOD and LOQ calculations (0.625 µM and 2.084 µM). Recoveries between 97.5 % and 98.0 % with RSD between 2.32 % and 2.07 % were found. This confirms the potential of the sensor for accurate and reliable MT detection in complex sample matrices.

Keywords: Melatonin; Analysis; Electrochemistry, Imprinting technology.

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Electrochemical Determination of Uric Acid by Graphene Oxide-Zinc Oxide Nanocomposite Modified Single-Use Electrodes

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Uric acid (UA), which is involved in many physiological processes in the human body, is produced daily in the body and the excess amount of this compound is excreted through urine [1]. Uric acid levels in human serum that are higher or lower than the reference range can cause various health problems such as liver diseases, nephritis, multiple sclerosis and diabetes [2].

Metal oxides and carbon-based materials are frequently used materials in electrochemical biosensing applications [3-5]. Different nanostructured materials exhibit enhanced electrocatalytic properties with chemical docking and composite formation.

This study aims to evaluate using GO-ZnO nanocomposite modification onto the surface of graphite electrodes for the rapid and sensitive detection of uric acid. GO-ZnO nanocomposite was earlier synthesized by Prof. Sezgin Bakirdere and his research group [6] that was used in this study as a modification material for single-use graphite electrodes. Firstly, the electrochemical behaviour of GO-ZnO nanocomposite modified electrodes was investigated. Under optimised experimental conditions, the detection of uric acid was carried out using differential pulse voltammetric (DPV) technique [7]. This study reported a low-cost and easy-to-use experimental procedure resulting with shorter detection time by using disposable electrodes.

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Keywords: Graphene oxide; Zinc oxide; Electrochemical biosensor; Uric acid detection.

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Impedimetric Immunosensor Developed for SARS-CoV-2 Spike S1 Protein

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Following the onset of the COVID-19 pandemic, there was a significant focus on developing sensitive and selective bioanalytical assays for the rapid detection of the highly pathogenic SARS-CoV-2 virus responsible for COVID-19. The SARS-CoV-2 spike protein has two regions: S1 and S2. As the S1 region of the spike protein interacts with the host cell receptors, it permits the SARS-CoV-2 virus to enter the cell [1-3]. In the COVID-19 pandemic, various electrochemical biosensor studies have been conducted [4-6]. In this study, we designed a label-free immunoassay combined with impedimetric detection to target the spike S1 protein [4]. To accomplish this, the capture antibody specific to the S1 protein (Cab-S1) was first anchored to the electrode surface. When a sample containing the spike S1 protein was introduced, a specific immunoreaction occurred, driven by the interaction between the antibody and its antigen. With the impedimetric immunosensor, the detection limit for S1 protein was found to be 0.23 ng/mL in the linear concentration range of S1 protein from 0.5 to 10 ng/mL. The developed impedimetric immunosensor has some advantages as easy to use, cost-effective. These features provide significant advantages over traditional analytical methods, enabling individuals to perform the point of care applications.

Keywords: SARS-CoV-2 S1 protein; electrochemical immunosensors; electrochemical impedance spectroscopy; COVID-19

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Development of Electrospun MXene-Incorporated PVDF Nanofibers for High-Performance Biosensor Applications

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MXenes possess extraordinary attributes that make them highly attractive for electrochemical biosensor fabrication. Their successful integration with diverse materials such as polymers, carbon nanotubes, and metals is evident in both the literature and industrial applications. [1]. The electrospinning technique offers a highly practical and straightforward approach for producing polymeric nanofiber composites containing $Ti_3C_2T_x$ (MXene). The mechanical stretching that occurs during nanofiber formation reduces $Ti_3C_2T_x$ aggregation, enabling the fabrication of homogenous nanofibers. Consequently, the electroactive area of the resulting composites is enhanced [2-3]. The surface properties of $Ti_3C_2T_x$ facilitate its facile integration with other materials such as polyvinylidene fluoride (PVDF), thereby enabling the fabrication of a diverse range of novel nanocomposites. [4]. The incorporation of $Ti_3C_2T_x$ into PVDF nanofibers not only enhances the polymer's conductivity but also leads to improvements in its hydrophilicity, chemical stability, and electrochemical properties. These enhancements render the composite material advantageous for applications such as sensors [5], wearable biosensors, supercapacitor electrodes [6], and energy harvesters [7]. This study aimed to develop MXene-incorporated PVDF nanofibers via electrospinning for potential biosensor applications. A homogenous solution of PVDF and MXene was prepared and electrospun under optimized conditions. The resulting nanofibers were characterized using SEM, SEM-EDX, and XRD techniques. SEM images revealed a uniform fiber morphology with an average diameter of 448 nm. SEM-EDX analysis confirmed the homogenous distribution of MXene within the PVDF matrix. XRD analysis further validated the successful incorporation of MXene and the semi-crystalline nature of the PVDF. These structural characteristics suggest that the MXene/PVDF nanofibers possess desirable properties for biosensor applications, such as high surface area, enhanced conductivity, and catalytic activity. Future work will involve integrating these nanofibers into biosensor platforms and conducting performance tests to evaluate their sensitivity and selectivity towards specific biomarkers. Additionally, the hypothesized properties of high surface area, enhanced conductivity, and catalytic activity will be experimentally verified.

Keywords: MXene; electrospinning; sem-edx; nanofiber.

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Electrochemical Biosensing of DNA Interaction with Mitomycin C using Halloysite Nanoclay-Ionic Liquid Nanocomposite Modified Electrodes

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Halloysite nanotubes (HNTs) have gained attention as promising materials for biosensing due to their unique tubular structure, high aspect ratio, and large surface area [1]. Their natural abundance, biocompatibility, and ease of surface modification make them ideal candidates for such applications [2,3]. Integrating ionic liquids (ILs) with HNTs enhances their electrochemical properties by providing a conductive medium that facilitates electron transfer and improves biosensor sensitivity [3,4]. Electrochemical biosensors have a wide range of applications, including detecting DNA-drug interactions, DNA hybridizations, and specific biomolecules, pathogens, or environmental toxins. These applications have significant implications for medical diagnostics, environmental monitoring, and food safety [5,6]

Mitomycins, a class of antibiotics derived from *Streptomyces caespitosus*, include Mitomycin C (MC), the most extensively studied due to its broad-spectrum antitumor effects, particularly against solid tumors such as those in the breast, stomach, esophagus, and bladder. Consequently, MC is widely used in clinical chemotherapy treatments for cancer [7,8].

This study aims to develop DNA biosensor using HNT/IL nanocomposite-modified electrodes and to explore its application on electrochemically monitoring DNA-Mitomycin C interaction. The HNT/IL nanocomposite-modified electrodes were first prepared [3]. The DNA biosensor was then developed and characterized using electrochemical techniques. The experimental conditions such as DNA and MC concentrations, interaction time etc. were optimised. The interaction between DNA and MC was investigated by measuring the changes in the electrode's response before and after interaction.

Keywords: Electrochemical DNA Biosensor, DNA-anticancer drug interaction, Halloysite Nanoclay, Ionic Liquid

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Fabrication of an Electrochemical Biosensor Utilizing Protein Phosphatase Enzyme Inhibition

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Microorganisms that are photosynthetic and found all over the planet are called cyanobacteria. They have the ability to suppress a variety of ecosystems, and certain strains have the ability to create toxins (cyanotoxins) and other metabolites that offer a serious risk to people and animals by contaminating water used for drinking, watering crops in agriculture, recreational activities, and cultivation [1]. A family of cyclic peptides with six amino acid residues, anabaenopeptins (APs) are among the most frequently occurring cyano-peptides found in the environment. They have been shown to have inhibitory effect against phosphatases and proteases. Taking this into consideration, an electrochemical screen-printed biosensor is being developed for observing the inhibition of the protein phosphatase enzyme (PP2), using the common substrate, sodium phenyl phosphate dibasic dihydrate (NaPPDD), as an inhibitor of the reaction between the enzyme and anabaenopeptin B (AP-B) [2]. Using phosphate buffer solution pH 7.4 as the working solution, cyclic voltammetry and chronoamperometry were used to evaluate the performance of the constructed biosensor. The outcomes were examined both prior to and after the AP-B inhibitor was incubated. Numerous parameters were optimized, including the concentrations of the substrate and enzyme, the period of time the inhibitor was set aside, the time frame of the enzymatic reaction, and the inhibitor's concentration. After thorough experimentation, the most favorable response was observed at a concentration of 5 mM, with an LOD of 0.26 mM and an LOQ of 0.87 mM.According to preliminary findings, these biosensors have the potential to be extremely useful instruments for identifying this type of organisms in environmental fields.

Keywords: Biosensors; Enzymatic inhibition; Electrochemistry.

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A Nanobiomaterial as a Novel Detection Pad Material for Lateral Flow Assays: An Ongoing Study

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Lateral Flow Assays (LFA), one of the paper-based biosensors, are seen as an ideal and analytical technology to overcome the detection challenge of human sera (blood, urine or body fluids) containing different plasma proteins and to shorten the time to result [1]. LFA consists of four basic components: sample pad, conjugation pad, detection pad (nitrocellulose membrane) and waste pad. The nitrocellulose membrane is an important component of the LFA system where signals are generated. The performance of the nitrocellulose membrane directly affects the accuracy and reproducibility of a test result [2]. The main characteristics of the membrane are that it facilitates a homogeneous flow, provides a functionalizable solid surface to capture the bioreceptor, and exhibits low non-specific interactions.

The main aim of this study is to realize the local production of nano-nitrocellulose membrane, an alternative to nitrocellulose membranes, which are the basic material of rapid diagnostic kits, with a natural bacterium and to develop the material that offers the possibility of determination of the obtained membrane in LFA. Bacterial nanocellulose (BNC) was obtained from *Acetobacter xylinum* bacterial culture. BNC has various morphologies and has properties such as flexibility, high crystallinity and biodegradability. It also exhibits distinctive properties such as biocompatibility, optical transparency, hydrophilicity, high porosity, and high surface area with hydroxyl-containing groups and high mechanical strength [3]. Nitration process was applied to the obtained BNC. The synthesized Nitrated Bacterial Nanocellulose (nBNC) is preferred over the nitrocellulose membranes available in the market due to its feature of containing nanoscale fibers and the large surface area provided by the nanoscale, such as highest antibody binding and increasing sensitivity, preventing non-specific interactions, reducing the need for detergent (surfactant) for conjugated nanomaterial release on the membrane surface. FT-IR, FESEM and BET analyses were performed separately for BNC and nBNC synthesized in the study. In the literature, the most widely used nanomaterial for LFA is gold nanoparticles (AuNPs) due to ease of production, long-term stability, biocompatibility and its sharp red color that can be easily identified even with the naked eye [4]. In this study, conjugated AuNPs were used. In the experiments, surfactant quantity optimization studies were performed for the sample and waste pads, and optimization studies were performed with surfactant-free but bovine serum albumin including for the nitrocellulose membrane. Visualizations were created for the time-dependent progress of these optimizations based on different ratios and contents, and the selection was made depending on the appropriate flow time of conjugated AuNPs. Studies are ongoing within the scope of the project.

Keywords: Bacterial nanocellulose, biosensor, detection pad, lateral flow assay.

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